JAN 5 1925

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An Illustrated Weekly Journal.

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LIMITED.
See Advertisement page 60, Dec. 12. 2402

Matthew Paul & Co., Ltd.,
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For Production of SHEET METAL WORK, COINAGE, CARTRIDGES AND GUNPOWDER.
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Technical matter of all kinds accurately typed from rough drafts. Duplicating, facsimile typewriting, translations from and into European languages. Expert Operators sent out.
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Engineering Salesmanship

and SALES MANAGEMENT.—Write for brochure describing our special Course of Training for posts of unlimited scope in this lucrative field.—DIRECTOR, Institute of Engineering Salesmanship, 333, Oxford Road, Manchester. 2431

TENDERS.

CITY OF LIVERPOOL.

TRAMWAY MATERIAL.

The Corporation are prepared to receive

Tenders for the Supply and

DELIVERY of:—
COPPER BONDS
TIMBER SLEEPERS.

Firms are requested to state clearly, when making application for the necessary Tender Forms, the name of the material for which they desire to be furnished with Tender Form.

Duplicate Forms of Tender for record purposes will NOT be supplied.

Tender Forms will be forwarded UPON RECEIPT OF APPLICATION IN WRITING to:—

The City Engineer,
Municipal Buildings, Dale Street,
Liverpool.

Tenders must be sealed and enclosed in the official envelopes provided, endorsed in accordance with the instructions given on the Form of Tender, and FORWARDED THROUGH THE POST, addressed to:—

The Town Clerk,
Municipal Buildings, Liverpool.

LATEST TIME AND DATE FOR RECEIPT OF TENDERS:—TEN O'CLOCK A.M. ON FRIDAY, THE 2ND JANUARY, 1925.

WALTER MOON,
Town Clerk.

15th December, 1924. G 722

TAF FECHAN WATER SUPPLY BOARD.

PIPE LAYING—CONTRACT No. 3.

The Taf Fechan Water Supply Board are prepared to receive

Tenders from Competent

Persons for the laying of about 21 miles of steel and cast iron pipes of 37 inch and smaller diameters together with ancillary works in the Counties of Brecknock and Glamorgan, and for the construction of a break pressure tank.

Drawings may be seen, and Instructions to Tenderers and Specifications and Bill of Quantities obtained on and after the 23rd December, 1924, at the Office of Sir ALEX BINNIE, SON & DEACON, 30, Buckingham Gate, Westminster, S.W., on payment of a cheque for £5 made out to the Taf Fechan Water Supply Board, which amount will be returned on receipt of a *bona fide* Tender.

Sealed Tenders, endorsed "Tender for Pipelaying" should be delivered at my Office at or before Noon, on Thursday, the 15th day of January, 1925.

The Tenders so sent in are to be accompanied by the Bill of Quantities fully priced out, and the Board do not undertake to accept the lowest or any Tender, or to defray any expenses in connection with Tendering, and will only consider such Tenders as are sent in by Contractors who have previously executed works of a similar kind and magnitude.

J. COLENSO JONES,
Clerk to the Board.

Board's Offices,
101, High Street,
Merthyr Tydfil. G 683

ADMINISTRATIVE COUNTY OF LONDON.

DISPOSAL OF SECOND-HAND BOILER.

The London County Council invites

Offers for the Purchase and

REMOVAL from the Stores Department Depot at Portland Avenue, Stamford Hill, London, N. 16, of ONE SECOND-HAND BOILER, to the following specification:—

Second-hand Multitubular Semi-portable Loco. type Boiler, by Davey Paxman. Barrel, 9 ft. 8 ins. by 3 ft. 8 ins. Length of Boiler, excluding smoke box, 7 ft. 7 ins. Fire Box Casing, 3 ft. 10 ins. wide, 4 ft. 2 ins. deep, 6 ft. 11 in. high. 52 tubes, 2½ ins. internal diameter. Working pressure 150 lb. Complete with feed pump, double lever safety valves, two water gauges, and one circular pressure gauge (300 lb.).

The Boiler may be inspected at the depot on any week day (except Saturday) between the hours of Ten a.m. and Four p.m. on production of permit to view.

Applications for permits, as well as offers to purchase, must be addressed to the Chief Officer of Stores, The County Hall, Westminster Bridge, London, S.E.1.

The Council does not bind itself to accept the highest or any Offer.

Offers must be delivered at the County Hall by not later than Nine a.m., on Monday, 5th January, 1925.

JAMES BIRD,
Clerk of the London County Council. G 707

METROPOLITAN ASYLUMS BOARD.

The BOARD invite

Tenders for the Opening Out,

REPAIRING and CLOSING UP, of the ENGINES and AUXILIARY MACHINERY of the RIVER AMBULANCE STEAMER "MALTESE CROSS," in accordance with specification prepared by Mr. THOMAS COOPER, M.I.C.E., M.I.M.E., Engineer-in-Chief to the Board.

Specification, conditions of contract, and form of Tender may be obtained at the office of the Board, Victoria Embankment, London, E.C.4.

Tenders, addressed as directed on the Form, must be delivered at the Office of the Board not later than Ten a.m. on WEDNESDAY, 31st December, 1924.

G. A. POWELL,
Clerk to the Board. G 723

BOMBAY, BARODA & CENTRAL INDIA RAILWAY COMPANY.

ELECTRIFICATION OF BOMBAY SUBURBAN LINES.

The Directors are prepared to receive

Tenders for the Supply of

the following PLANT:—
IMPEDANCE BONDS for Track Circuiting.
Fee for Specification £2 per copy.

Specifications and forms of Tender (which must be submitted in duplicate) may be obtained at this Office on payment of the fee for the Specification, which payment will not be returned.

Tenders must be sealed and addressed to the undersigned, marked "Tender for Impedance Bonds," and delivered not later than Noon on Tuesday, January 20th, 1925.

The Fee should accompany any application by post. Cheques and postal orders should be crossed and made payable to the Bombay, Baroda & Central India Railway Company.

The Directors do not bind themselves to accept the lowest or any Tender.

The Consulting Engineers, to whom application for any further technical information may be made, are Messrs. MEAD & MCLELLAN, 33, Victoria Street, Westminster, S.W.1.

S. G. S. YOUNG,
Offices: The White Mansion, Secretary.
91, Petty France,
Westminster, S.W.1.

18th December, 1924. G 738

COUNTY OF LONDON.

The London County Council invite

Tenders for the Supply and

DELIVERY in London of
(a) About 3700 tons of STANDARD STEEL GIRDER TRAMWAY TRACK RAILS, LIPLESS TRACK RAILS, and FISH-BOLTS, and, alternatively, of about 4700 tons of such Rails and Bolts.
(b) About 700 tons of CONDUCTOR TEE RAILS, the supply and delivery of which will form the subject of a separate contract.

Persons desiring to Tender may obtain the drawings, specifications, bills of quantities, Forms of Tender, and other particulars on application to the Chief Engineer of the Council, at the Old County Hall, Spring Gardens, S.W.1, upon payment of the sum of £2 in each case. This amount is to be paid by cheque or draft to the order of the London County Council and will be returnable if a *bona fide* Tender is submitted and not subsequently withdrawn. All particulars may be obtained on application at the Old County Hall prior to the payment of this fee.

Tenders are to be delivered to the Clerk of the Council at the County Hall, Westminster Bridge, S.E.1.

No Tender received after Four p.m. on Monday, 19th January, 1925, will be considered.

The Council does not bind itself to accept the lowest or any Tender.

JAMES BIRD, G 732
Clerk of the London County Council.

URBAN DISTRICT COUNCIL OF FLEET (HANTS).

EXTENSION OF EXISTING SEWERAGE AND SEWAGE DISPOSAL WORKS FOR FLEET.

UNEMPLOYMENT RELIEF WORKS.
GENERAL CONTRACT.

The Urban District Council of Fleet invite

Tenders from Responsible and

Experienced Contractors for the CONSTRUCTION of these WORKS, which comprise several miles of Cast Iron and Stoneware Sewers, Brick, Concrete and Cast Iron Manholes, Flushing Tanks, Ventilating Shafts and Columns, Cast Iron Rising Main, Air Mains, and additions to the Sewage Disposal Works, and other incidental work.

A copy of the Specification and Form of Tender, and Bills of Quantities may be obtained and the drawings inspected, on and after a date to be communicated to persons Tendering, on application, in writing, to MAJOR T. J. MOSS-FLOWER, Civil Engineer, 28, Victoria Street, Westminster, S.W., and Carlton Chambers, Bristol, at his Bristol Office, on deposit of a £10 Bank of England Note, which will be refunded provided a *bona fide* Tender be received, and is not withdrawn before the sealing by the Council of one of the Tenders, and provided also that all documents supplied be returned to the Engineer.

The Contractor carrying out the work will be required to comply with the regulations of the Unemployment Grants Committee with regard to the employment of labour during the performance of the Contract, and the work must be actively commenced by 12th January, 1925.

Sealed Tenders, endorsed "Tender for Fleet Sewerage and Sewage Disposal Works, General Contract," are to be delivered at the Council Offices, not later than Noon on the 7th January, 1925.

The lowest or any Tender will not necessarily be accepted.

Dated this 15th day of December, 1924.

(By Order)
ERNEST NASH,
Solicitor & Clerk to the Council.

Council Offices,
FLEET (Hants). G 715

The Director-General,

INDIA STORE DEPARTMENT, Branch No. 16, Belvedere Road, Lambeth, S.E.1, REQUIRES
ELECTRIC CELLS for Railway Carriages.
9, 15, 21 plates.
Tenders due on the 2nd January, 1925.
Tender Forms obtainable from above. G 729

APPOINTMENTS OPEN.

SAFETY IN MINES RESEARCH BOARD.

APPOINTMENT.

The Safety in Mines

RESEARCH BOARD REQUIRES an INVESTIGATOR to carry out work on the strengths of various structures for the support of underground workings in Coal Mines.

Applicants must possess a University Degree or its equivalent in Engineering. Preference will be given to ex-service candidates.

The appointment is a temporary one, in London, for a period of one year at an inclusive salary of £250 per annum.

Forms of application, which must be returned not later than 31st December, can be obtained from the UNDER-SECRETARY FOR MINES, Establishment Branch, Mines Department, Dean Stanley Street, London, S.W.1. G 720

COUNTY BOROUGH OF WEST HAM.

WEST HAM MUNICIPAL COLLEGE,
Romford Road, Stratford, E.15.

Applications are Invited for

the POST of full-time ASSISTANT TEACHER in the Department of Engineering from candidates with University Degree and works experience. Salary in accordance with the Technical Burnham Scale for the London Area less 5 per cent., and subject to deduction for superannuation. Applicants must be members of a recognised Teachers' Organisation. Forms of application may be obtained from the Principal and should be returned not later than Monday, 5th January, 1925.

GEO. E. HILLEARY,
Town Clerk.

Education Department,
95, The Grove, Stratford, E.15.
3rd December, 1924. G 636

LIVERPOOL EDUCATION COMMITTEE.

CENTRAL TECHNICAL SCHOOL.

MARINE ENGINEERING DEPARTMENT.

Applications are Invited for

the POSITION of ASSISTANT INSTRUCTOR in the Marine Engineering Department of the Central Technical School.

Candidates should have an Extra First Class Engineer's Certificate (Board of Trade), or a University Degree in Engineering, together with a First Class Engineer's Certificate (Board of Trade).

A knowledge of oil fuel and oil motor ships is desirable.

The salary will be at the rate of £300 per annum, subject to five per cent. deduction for superannuation.

Form of application, together with further particulars, may be obtained from the Director of Education, 14, Sir Thomas Street, Liverpool. The last date for receiving applications is 22nd December, 1924.

WALTER MOON,
Clerk to the Local Education Authority. G 705

Assistant Locomotive

SUPERINTENDENT REQUIRED for the NIGERIAN GOVERNMENT RAILWAY for two tours of from 12 to 18 months' service with prospect of permanency. Salary £480 a year for the first three years, then £510, rising by annual increments of £30 to £720, and thence by annual increments of £40 to £920. Outfit allowance of £60 on first appointment. Free quarters and first-class passages and liberal leave on full salary. Candidates, age 25 to 35, should be of good education and preferably possess an approved Engineering Diploma. They should have had a thorough training in the workshops of a British Railway or well-known Locomotive firm, should be conversant with the repair and erection of Locomotives, carriages and wagons and be well up in drawing office work, and have had running experience. Preference will be given to applicants who have acted in a supervising capacity.—Apply at once, by letter, stating age and particulars of qualifications and experience, to THE CROWN AGENTS FOR THE COLONIES, 4, Millbank, Westminster, S.W.1, quoting M/Nigeria 13159. G 710

Technical Assistant Wanted

for Aircraft Structural Calculations. Sound Theoretical training required but previous aircraft experience not essential.—Apply, giving age, qualifications and salary required, to BOULTON & PAUL, LTD., Norwich. G 682

Sales Manager Required by

firm of Engineers manufacturing Petrol, Paraffin House Lighting Sets, must have established connection.—Address, stating fully, age, experience and salary required, G 693, Offices of ENGINEERING.

The National Omnibus and

TRANSPORT COMPANY LIMITED, REQUIRE an ASSISTANT WORKS MANAGER, age about 30-35, Manufacturing experience and good knowledge of body work, running repairs and maintenance of rolling stock essential.—Applications, giving full particulars of experience and salary required, to be addressed to the SECRETARY, 36a, Brompton Road, S.W.3. Envelopes to be marked "A.W.M." G 695

Engineering. — Small and

Old-established Business, in Leeds, has OPENING for GENERAL MANAGER—small capital may be invested but not essential for first-class man. State age, salary and qualifications.—Address, G 702, Offices of ENGINEERING.

Civil Engineering

ASSISTANT REQUIRED, with good knowledge and experience in design of steel, concrete and other structures. Preference will be given to an ex-Service man. Salary £217s. 6d. per week plus Civil Service Bonus, making the present total salary approximately £232 per annum. Applications, with full particulars of qualifications and at least two recent testimonials, are to be forwarded to the SUPERINTENDING CIVIL ENGINEER, H.M. Dockyard, Portsmouth. G 721

Production Engineer for

complete supervision and planning of quantity production of a Petrol Pump. Must be primarily a thoroughly good mechanic; must have office experience. Buying and inspection experience are of utmost value. London District.—Send full particulars, salary required, etc., to N.A., c/o J. W. VICKERS & CO., LTD., 5, Nicholas Lane, E.C.4. G 734

CITY OF SHEFFIELD—WATER DEPARTMENT.

APPOINTMENT OF ASSISTANT ENGINEER.

Applications are Invited for

the APPOINTMENT of THIRD ENGINEERING ASSISTANT.

Age about 25 years.

Candidates must be qualified Engineers, have held a similar position, and have had practical experience in connection with the distribution of water, the maintenance of reservoirs and works, distributary pipes, and the methods employed in the detection and prevention of waste.

Commencing Salary £350 per annum. (Grade III.)

Applications, stating age, qualifications and experience, accompanied by copies of three recent testimonials endorsed "Engineering Assistant," to be sent to me not later than Monday, 13th January, 1925.

WILLIAM TERREY,
General Manager.

Town Hall, Sheffield.
17th December, 1924. G 735

Executive Engineer

REQUIRED by the GOVERNMENT of SIERRA LEONE, in the PUBLIC WORKS DEPARTMENT, for two tours of not less than 12 nor more than 18 months' continuous residential service. Salary £600 a year. Free quarters and passages and liberal leave on full salary. Candidates aged 28-35, should have served articles with a Member of the Royal Institute of British Architects, and have passed the examination qualifying for Associate Membership of that Institute, or possess the diploma of some recognised college which is accepted by that Institute as exempting candidates from taking the examination of the Institute. Must be first-class Draughtsman, capable of designing and carrying out buildings, taking out quantities, preparing details and specifications, and must be competent to execute building surveys, set out buildings and and lay out roads. Other qualifications being equal preference will be given to candidates who have had experience of the work of a Civil Engineer in the construction and carrying out of general public works.—Apply at once, by letter, stating age, qualifications and experience, to THE CROWN AGENTS FOR THE COLONIES, 4, Millbank, Westminster, S.W.1, quoting M/13190. G 711

THE MUNICIPALITY OF SINGAPORE.

STRAITS SETTLEMENTS.

WATER ENGINEER.

The Municipal Commissioners of Singapore require a

Water Engineer, Age 35-43,

on a four years' agreement, with possible extension. Candidates must have had considerable experience, in a responsible capacity, of the design and maintenance of important Waterworks, including Impounding Reservoirs, Pumps, Slow Sand and Mechanical Filters, Service Reservoirs, Detection of Waste and the Distribution of Water throughout a large Town. The selected candidate will be required to control the whole of the Water Department and to advise the Commissioners on all matters regarding the water supply of the City, apart from a large new water scheme now in progress under a Westminster firm of Engineers. He must be a Corporate Member of the Institution of Civil Engineers, having responsible experience with a Water Company or the Water Department of a Public Authority. Administrative experience is an essential of this appointment. The population supplied with water is about 350,000 and the whole supply is impounded and pumped. There is a considerable area of open sand filters but the filtration capacity is to be greatly extended, and mechanical filters are under consideration. Two pumping engines, each of about 8½ million gallons per day, are about to be installed, with boilers and auxiliary plant. There is a salt water pumping and distribution system. The total expenditure of the Water Department in 1923 was about £250,000, and the average daily consumption was nearly 11,000,000 gallons of which a large portion is waste and must be reduced.

Salary $12,000 for the first, $13,200 for the second, $14,400 for the third, and $15,600 for the fourth year, paid monthly, in dollars, the currency of the Colony, the value of the dollar being two shillings and fourpence sterling. The pay of the appointment for the first year at this rate would be £1,460, rising to a maximum of about £1,960 in five years. Such local transport allowance as may from time to time be sanctioned by the Commissioners, will be paid. Free passage will be provided with half-pay during the voyage out. The selected candidate must pass a medical examination.

Applications, stating whether married or single, age, and place of birth, and giving details of education, training and experience, particularly in Waterworks, and referring to all the above requirements in detail, accompanied by copies (only) of testimonials, to be lodged with Messrs. G. G. LINDSAY & PEIRCE, M.M.Inst.C.E., 180, Hope Street, Glasgow, Agents for the Commissioners, not later than Tuesday, 23rd December, 1924. G 697

GEAR-TOOTH TESTING.—II.

By JOSEPH HORNER.

A REFINEMENT that is introduced into several of the later gear-testing machines is that for testing the accuracy of the involute curves. Teeth may be correctly spaced and of equal thickness, and the pitch circles concentric with the bore, while the tooth profiles vary from a true involute. It is the detection of the last error which is provided for in a machine made by the Illinois Tool Works, of Chicago, U.S.A. It is based on the principle that the curve is produced by the unwinding of a string from a cylinder—the base circle. The circle is represented by a disc, and the tangential cord by one edge of a flat block on which an indicator is mounted, terminating in a contactor point located in the plane of the tangent.

Fig. 10 shows the appliance testing the tooth profile of a spur gear. The base disc is seen behind the gear, with a wire that lies in a groove in its periphery. The diameters of the discs used are governed by the number of teeth, the pitch, and the pressure angle. The base diameter is equal to the pitch diameter, multiplied by the cosine of the pressure angle. The depth of the groove is equal to one-half the diameter of the wire or band used. The edge of the indicator block has a groove of the same depth as the groove in the disc. This allows the tangent to roll directly on the base disc, and by having one-half the wire in each element, no slipping takes place from bending of the wire.

A base disc suitable for the gear having been selected, this and the gear are placed on the stud in the table of the machine, and the wire bands are adjusted and tightened. The gear is then turned until the face of a tooth acts on the contactor, and turns the indicator pointer through about one-half a revolution. The gear and the base disc are then locked together with a nut on the stud. The tangent block is rolled on the base disc to cause the contactor to follow the involute curve of the tooth. The movement is transmitted through the multiplying lever seen below to the pointer of the indicator at the right. If the involute curve is accurate the pointer of the indicator will not be deflected. Such close limits to accuracy are not easily obtained, but it is found that a variation of a fraction of one-thousandth of an inch is not noticeable in the running of the gears. Deflections may be recorded on a diagram.

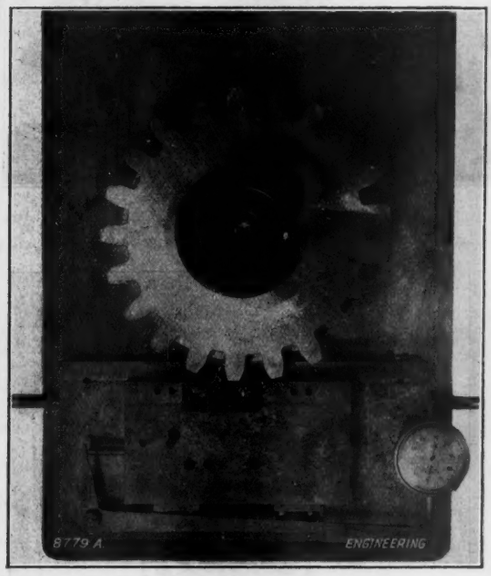


FIG. 10.

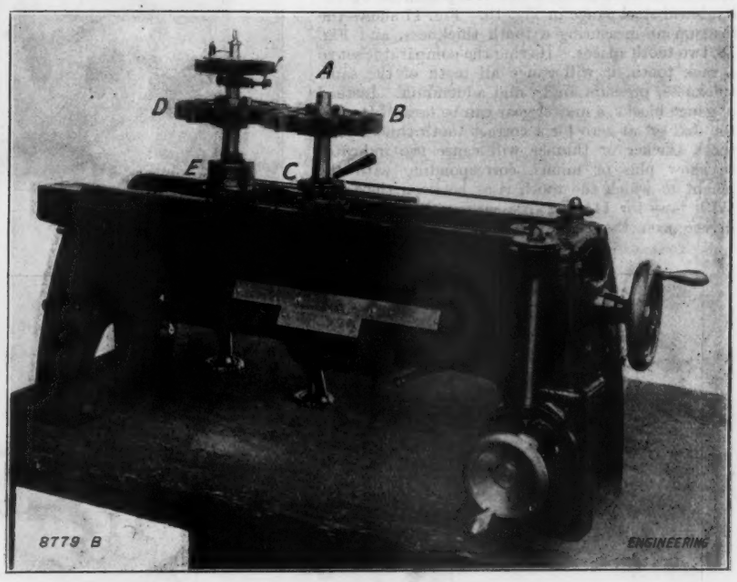


FIG. 11.

Fig. 12.

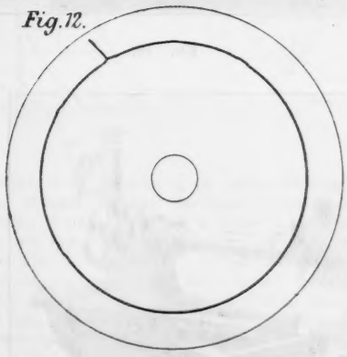
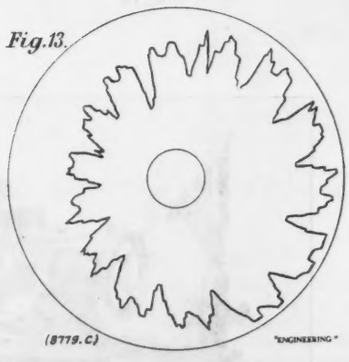


Fig. 13.



The Saurer machine, by Sulzer Brothers, of Bedford-square, London, is shown by Fig. 11 above. It tests the running accuracy of a pair of gears, but a supplementary appliance is employed to measure the distance from the profile of one tooth to that of the next. The action of the machine is based on the fact of uniform angular velocity being transmitted between two discs representing the base circles of a pair of gears, by means of a flexible band. In the machine, ground discs are connected with a crossed steel band, and are mounted on the arbors that carry the gears under test. In Fig. 11, the shaft A carries one of the gears B, and has a ground steel disc at C. The second gear D is mounted on a hollow shaft, which is free to move relatively to an inner shaft carrying the other ground disc E, that is connected with a crossed steel band to the disc C. When motion is imparted by the movement of the band, the inner shaft carrying the disc E, and the outer shaft that carries the gear wheel D will both rotate in the same direction, and relative motion will only occur if the motion imparted by the gears differs from that produced by the discs and band. Such irregularities can only be due to inaccuracies in the gears. A multiplying mechanism records on a diagram any relative movements that occur between the inner and outer shafts. Fig. 12 is a diagram taken from a pair of wheels accurately ground. The curve is uniform. In Fig. 13 each tooth shows sharp variations as it comes into and leaves engagement. Each radial displacement recorded by the pencil indicates a variation in angular velocity ratio of the wheels which occurs when two particular teeth are in contact. It corresponds in the case of high speed gears, with additional loading on the teeth, and changes in the angular momentum of the two shafts. These changes can only be minimised by the production of teeth with the highest degree of accuracy.

Mention has been made in the previous article of the unsatisfactory character of measurements which take note of tooth thicknesses, and tooth spaces alone, without taking account of the distances to adjacent profiles. The Sulzer instrument for measuring tooth to tooth distances is shown by Fig. 14 on page 822. Measurement is taken along the common normal to the two profiles, along which contact takes place. The necessary adjustments are effected with a screw and quadrant. Contact is made with a fixed plane surface against one tooth and a movable ball against the other. This apparatus was evolved from a series of tentative schemes of measurement. The first tested tooth spaces, by the insertion of a ground cylindrical mandrel in a space, and the gear was rotated to bring the mandrel under a dial indicator. This was repeated for all the teeth and the readings were compared. This rendered the gaugings independent of the outside diameter, but they told nothing respecting the accuracy of the pitch. Then a method of measurement followed, to include tooth thickness and adjacent spaces. Two ground mandrels were located in the spaces, and on one an arm was clamped carrying a dial indicator, and this arm with the indicator was swung past the second mandrel, the maximum reading being noted. A comparison could thus be made between the centres of adjacent tooth spaces. Then the prototype, Fig. 15 of the instrument in Fig. 14 was designed. The two mandrels were replaced by two ball arms, one being fixed, the other movable, on a pivot, and acting through a series of levers on the plunger of the dial indicator. Comparisons could thus be made of the distances between the centre lines of the tooth spaces. Ball arms of various sizes could be fitted,

in order to measure distances at different heights of the teeth. Readings could be taken to 1/1,000 mm. The difference between this and the later instrument shown in Fig. 14 is that this, instead of measuring centres of tooth spaces deals with those profiles along the common normal where contact takes place. If these profiles and spaces are accurate, the running will not be affected by a moderate amount of backlash. If the teeth have as much as 0·4 mm., or 0·8 mm. play, this will be safer in view of the tendency of the gears to heat and to expand during case-hardening. Some clearance is better than running the risk of their jamming.

The gear tooth comparator by W. E. Sykes, of Slough, measures the degree of uniformity in tooth thickness, in pitch, and inaccuracy in profile. Its basis is the rack tooth, which is represented by the hardened steel gauge in Fig. 16. Fig. 17 shows the instrument measuring a tooth thickness, and Fig. 18, two tooth spaces. Having the comparator set to a rack tooth, it will gauge all teeth of the same thickness, pressure angle, and addendum. Instead of gauge blocks, a master gear can be used. Having the dial set at zero for a correct tooth thickness, a tooth thicker or thinner will cause the indicator to show plus or minus, corresponding with the height to which the tooth rises between the jaws. With jaws for 14½ deg. pressure angle teeth, each division on the dial indicates 0·0005 in. The is not important. The plunger of the indicator is set approximately central between the jaws. After having been set, the tightening of the knurled lock nuts follows, and the instrument is ready to be applied to the teeth. This takes no account of being used to test a gear on a machine, the second is the same mounted on a stand for the inspection of the teeth subsequent to machining. The teeth are embraced between a fixed and a movable jaw, corresponding with the flanks of a rack, while a

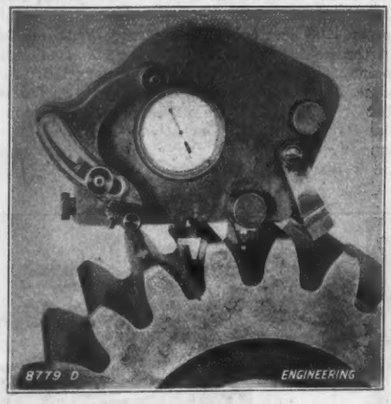


Fig. 14.

Fig. 15.

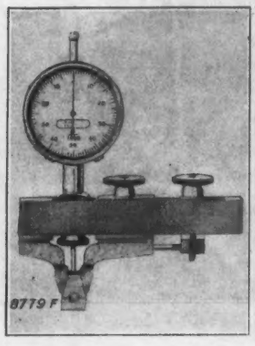


Fig. 16.

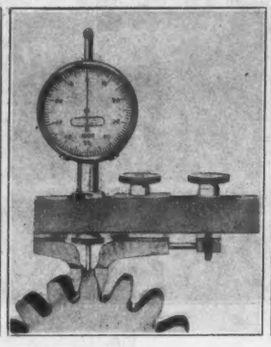


Fig. 17.

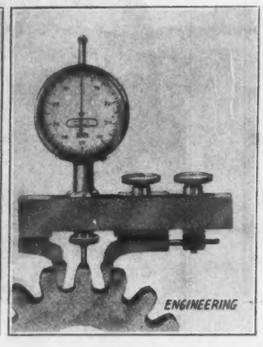


Fig. 18.

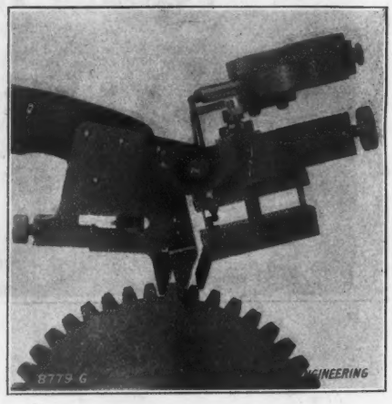


Fig. 19.

Fig. 20.

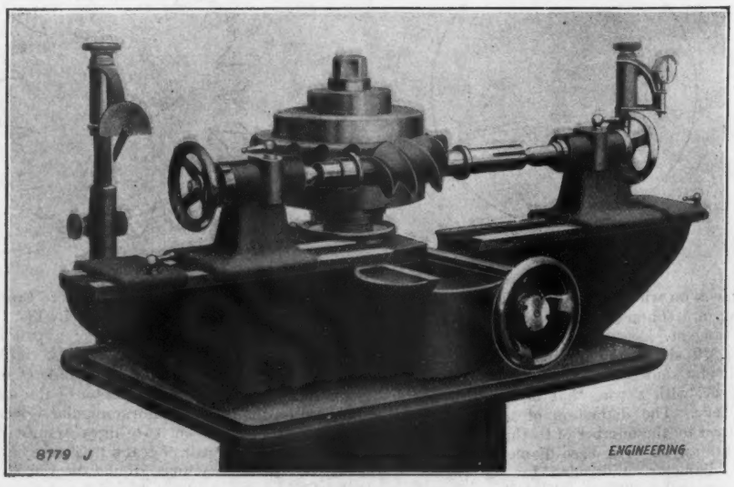


Fig. 21.

capacity of the instrument ranges from 12 d.p. to 1 d.p., or from ¼ in. to 3 in. circular pitch.

Referring to Fig. 17, it is seen that the jaws of the instrument have a tangential bearing on the tooth. The movable jaw to the right is set so that the ends of the jaws come between the pitch circle and the bottom of the tooth. The precise location the concentricity of the rim with the bore, which must be assured by other means. It is stated that the instrument will indicate appreciably on the hand of the dial variations of tooth thickness of 1/10,000 in.

Figs. 19 and 20 illustrate an Odontometer by the Pratt and Whitney Company, of Hartford, Conn., U.S.A. The first figure shows the instrument movable finger to the right is brought into contact with the outside of an adjacent tooth. Contacts take place along the line of action, and readings are made on a dial gauge.

In all the foregoing examples spur gears only have been the subjects of test. In the case of spiral gears, bevel gears, and worm gears the pairs are simply run together at their correct pitch

THE DESIGN OF OIL FUEL PIPE LINES.

Fig. 1. OIL FUEL. DENSITY CHART.

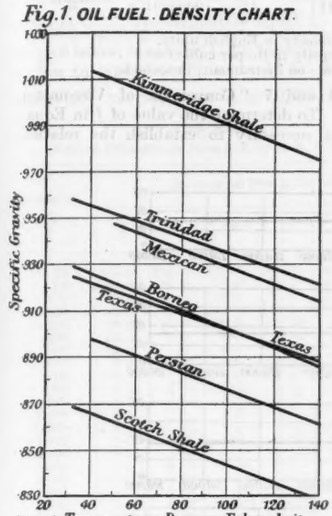


Fig. 2. CHART FOR CONVERSION OF READINGS ON S.G. HYDROMETER INTO WEIGHTS PER CUBIC FEET.

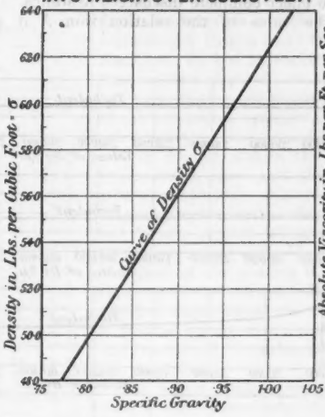


Fig. 3. VISCOSITY CHART N°1.

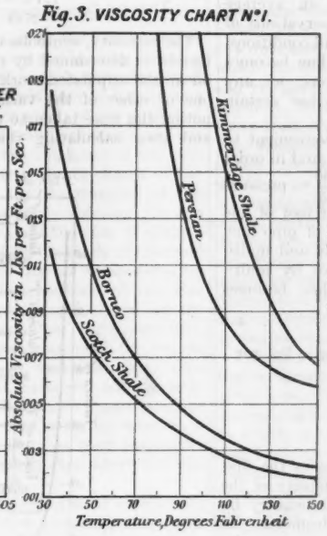


Fig. 4. VISCOSITY CHART N°2.

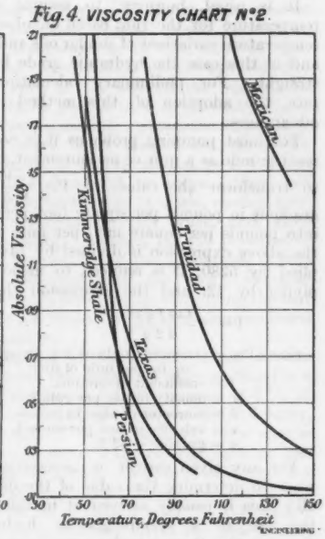


Fig. 5. VISCOSITY CHART N°3.

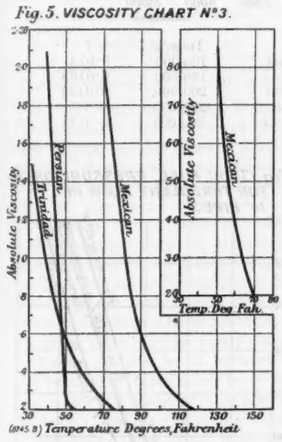


Fig. 6. CHART FOR CONVERSION OF VISCOMETER READINGS INTO ABSOLUTE ENGLISH UNITS.

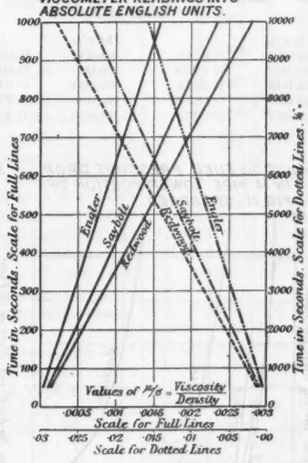


Fig. 7. OIL FUEL. CHART FOR CONVERSION OF VISCOMETER READINGS ON REDWOOD N°2.

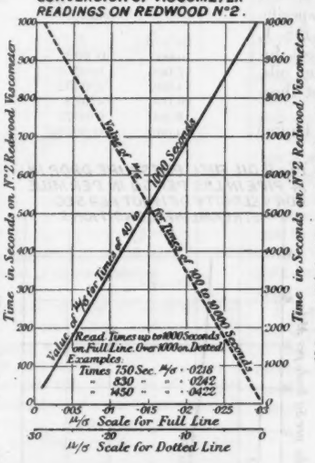
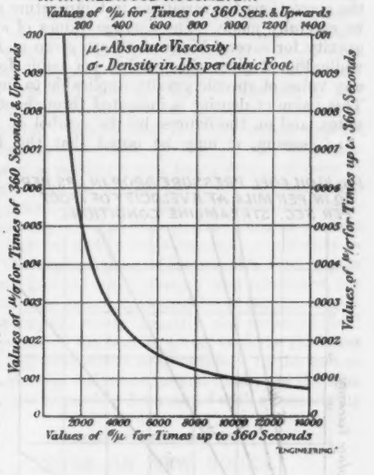

Time in Seconds on N°2 Redwood Viscometer
Value of μ/σ for Times of 40 to 1000 Seconds
Value of μ/σ for Times of 360 to 10000 Seconds
Read Times up to 1000 Seconds on Full Line. Over 1000 on Dotted
Examples
Times 750 Sec. μ/σ = ·0218
" 830 " " = ·0242
" 1450 " " = ·0422
μ/σ Scale for Full Line
μ/σ Scale for Dotted Line

Fig. 8. OIL FUEL. CHART SHOWING RELATION OF μ/σ & μ/σ FOR TIMES OF 36 TO 3600 SEC^s ON N°1 REDWOOD VISCOMETER.


Values of μ/σ for Times of 360 Secs. & Upwards
μ = Absolute Viscosity
σ = Density in Lbs. per Cubic Foot
Values of μ/σ for Times of 360 Seconds & Upwards
Values of μ/σ for Times up to 360 Seconds
Values of μ/σ for Times up to 360 Seconds

diameters, and the meshing of individual teeth is noted. Several of these instruments are manufactured. Worm threads can be tested in a machine shown in Fig. 21, and made by Messrs. David Brown and Sons (Hudd.), Limited. After the threads of the worm have been tested, its wheel can be brought into mesh, for which suitable radial and vertical adjustments are provided, and any inaccuracies in their engagement be noted. The worm is first tested with the dial indicator seen at the extreme right. The worm is mounted between centres, and the indicator brought over it, with the pointer set to zero. A spherical ball gauge of suitable size is set between the vertical spring plunger of the dial indicator, and the space between two worm threads. As the worm is revolved, inaccuracies in the threads will be transmitted to the pointer of the dial. A space too wide or too narrow will be denoted by the movement to one side or the other of the zero mark. The pressure angle is tested with a protractor plate, seen at the extreme left. The knife edge of the protractor is placed along the side of the worm thread on the linear section, and the angle is read off on the scale.

INSTITUTION OF PUBLIC LIGHTING ENGINEERS.—The Council of this Institution have selected Mr. C. S. Shapley of Leeds as President for 1925–26. The Leeds City Council at their last meeting decided to entertain the Institution on the occasion of its second annual meeting at a date to be fixed, and a committee has been appointed to make the necessary arrangements.

THE DESIGN OF OIL FUEL PIPE LINES.

By W. G. WATKINS.

(*Continued from page* 793.)

THE object of the present article is to indicate the main considerations underlying the design of pipe lines, and the series of charts accompanying this are for the purpose of facilitating the necessary calculations. The aim has been to render the various steps as easy as possible, and the formulæ adopted are in all cases reduced to the simplest possible expressions. Generally, the information contained in the Report of the National Physical Laboratory on Tests made on Fuel Oils, has been made use of for the construction of the various charts indicating density, viscosity and "streamline" flow, and for the calculation of pressure drop under "turbulent" conditions a modified formula has been used giving results per mile run of pipe line, which, for most pumping problems, is a more convenient unit than that usually adopted. It has been found that within a certain limited range of pipe diameters the pressure drop conforms approximately to an exceedingly simple relation of viscosity and diameter and for preliminary calculations, the constants arrived at will be found very useful, but they are applicable only for "streamline" flow and for the diameters stated, and in all cases the results should be checked either by the diagrams or by special calculations where the case is beyond their scope.

The main factors controlling the design are: (1) the length of the line; (2) required capacity of line per hour, or day; (3) proposed diameter; (4) topographical conditions of proposed route; (5) oil or oils to be handled and their physical properties; (6) pressure required at pumps; (7) distribution of pumping stations.

Conditions 1, 2, 3, and 5 will determine the frictional resistance, and from thence the pressure gradient (or drop) along the line from station to station.

As the physical conditions of the oil do not remain uniform, owing to falling temperature during the run from station to station, the hydraulic gradient will not be straight but curved, for as the temperature falls the viscosity increases, and with the change in viscosity the friction coefficient "f" will show constantly changing values. So long as the conditions of flow are unchanged, *i.e.*, either continuously "streamline" or continuously "turbulent," the value of "f" will continuously increase, with a corresponding steepening of the hydraulic gradient. If, however, the conditions should change, during the passage of the oil between stations from "turbulent" to "streamline" as a consequence of increased viscosity, "f" may show an increase in the first place, followed by a sudden drop on the change taking effect, and afterwards a further continuous increase as the oil cools still more under "streamline" conditions. The actual hydraulic grade line will, therefore, be more or less

complex, according to the temperature-distance-history of the oil under consideration.

It is usual, however, to assume an average temperature for the run, based on observations of temperature variations of similar oils and conditions, and in this case the hydraulic grade line becomes straight. For preliminary calculations, at any rate, the adoption of this method has certain advantages.

For most pumping problems it is convenient to use the mile as a unit of measurement, and in order to transform the value of $P = \frac{f \sigma v^2}{D\,2g}$ = pressure gradient in pounds per square foot per foot of line into pounds per square inch per mile of pipe line, the above expression is divided by 144 and multiplied by 5280. D is reduced to inches by multiplying by 12, and the expression then becomes

$$Pm = \frac{440\, f \sigma v^2}{d\, 2g} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad A$$

where Pm = pressure gradient (or drop) in lbs. per sq. in. per mile of line.
f = coefficient of friction.
σ = density in lbs. per cub. ft.
d = diameter of pipe in inches.
v = velocity in feet per second.
g = gravity = 32·2.

For any given case it is necessary in the first place to determine the value of the density of the oil; this is usually arrived at in this country by the use of a specific-gravity hydrometer. In America the Baumé hydrometer is more generally used. The specific-gravity hydrometer gives the specific gravity in relation to distilled water, and the corrections for variations in temperature should be carefully made. The average values of specific gravity for several kinds of oil are given in Fig. 1, while Fig. 2 gives the weights per cubic foot for any value of specific gravity applicable to fuel oils. This value of density is indicated throughout these notes, and on the figures, by the symbol σ.

In passing, it may be noted that the Baumé hydrometer is made in two types; one is called the "light Baumé" and the other "heavy Baumé." The former is suitable for most oils (which are of less than 1·000 specific gravity), the latter being used for liquids heavier than water. The relation between Baumé degrees and weights per cubic foot is given by the following formula:—

$$\sigma = \frac{8736}{130 + B}$$

where B = gravity in degrees on Baumé scale.

As the density varies somewhat with changing temperature, it is useful to know the average relation between density at a standard temperature, usually taken at 60 deg. F. and at any specified working temperature. If possible, this should be determined by actual test, but may be calculated from the following empirical formula, which agrees closely with the changes observed in American petroleum oils.

Let x_1 = density σ at 60 deg. F.
x = " at working temperature t

$$\text{Then } x = x_1 - \frac{121{\cdot}2 - x_1}{2713}\,(t - 60 \text{ deg.}) \quad . \quad B$$

The viscosity, symbolised by μ in these notes and figures, is determined by running off 50 c.c. of the oil at the stipulated working temperature through one or other of the various types of viscometer, noting the time taken to effect complete discharge and then calculating the value of the relation $\frac{\mu}{\sigma} = \frac{\text{Viscosity}}{\text{Density}}$ by the formula appropriate to the viscometer used.

Figs. 3, 4, and 5 give the viscosity values in absolute English units (foot-pound-second) for various oils in general use, while Figs. 6 and 7 give the numerical measure of viscosity $\frac{\mu}{\sigma}$ for any observed times of outflow for the various viscometers named, for times up to 10,000 seconds. From the value of $\frac{\mu}{\sigma}$ thus determined the value of μ can be ascertained by multiplying by σ.

The following formulæ will serve for converting the results of viscometer readings into absolute English units (foot pounds second):—

Saybolt (American) $\frac{\mu}{\sigma} = \cdot00000237\,t - \frac{\cdot00194}{t}$

Engler (Continental) $\frac{\mu}{\sigma} = \cdot00000158\,t - \frac{\cdot00403}{t}$

Redwood I (English) $\frac{\mu}{\sigma} = \cdot0000028\ t - \frac{\cdot00185}{t}$

" II (") $\frac{\mu}{\sigma} = \cdot0000291\ t - \frac{\cdot0129}{t}$

where μ = Viscosity in English units.
σ = Density in lb. per cubic foot.
t = Time on instrument, in seconds.

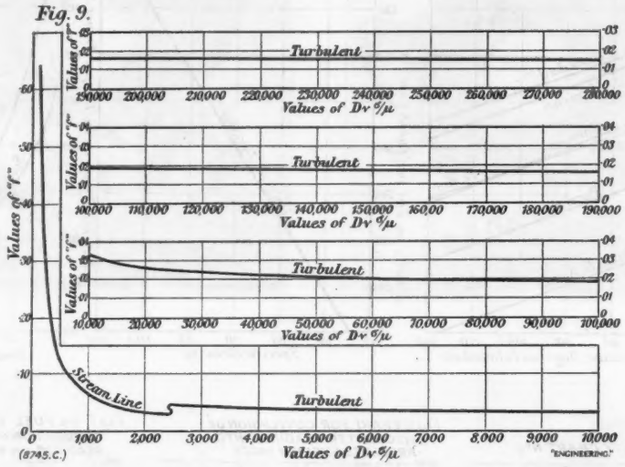
(See Figs. 6 and 7 "Conversion of Viscometer Readings.") To determine the value of f in Equation A it is necessary to establish the relation $\frac{\sigma}{\mu}$ and Fig. 8 gives this relation over a wide range, covering all likely cases.

Having determined $\frac{\sigma}{\mu}$ from Fig. 8 we are now in a position to ascertain the value of $\frac{D\,v\,\sigma}{\mu}$

where
D = Diameter of pipe in feet.
v = Velocity of flow in feet per second.

From the result of this, f may be found in Fig. 9 above the point corresponding to the value of $\frac{D\,v\,\sigma}{\mu}$*

Fig. 9.



Dv σ/μ	f	Dv σ/μ	f	Dv σ/μ	f	Dv σ/μ	f
10,000	0·032	25,000	0·0249	50,000	0·0208	100,000	0·018
12,000	0·0304	30,000	0·0238	60,000	0·02	150,000	0·0168
14,000	0·0292	35,000	0·0228	70,000	0·0195	200,900	0·0158
16,000	0·028	40,000	0·0219	80,000	0·019	250,030	0·015
18,000	0·0271	45,000	0·0213	90,000	0·0185	300,000	0·0144
20,000	0·0264						

Fig. 10. OIL FUEL. PRESSURE DROP IN LBS. PER SQ. IN. PER MILE AT A VELOCITY OF 1 FOOT PER SEC. "STREAMLINE" CONDITIONS.

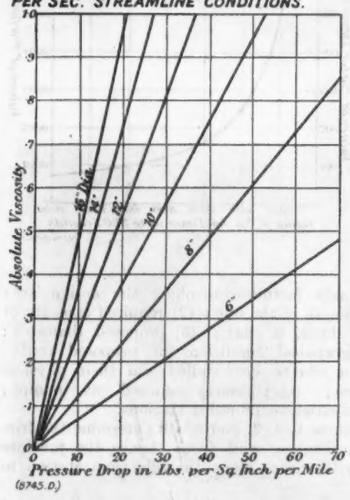


Fig. 11. OIL FUEL. PRESSURE DROP IN 14" PIPE IN LBS. PER SQ. IN. PER MILE FOR VELOCITY OF 1 FOOT PER SEC. "STREAMLINE" CONDITIONS.

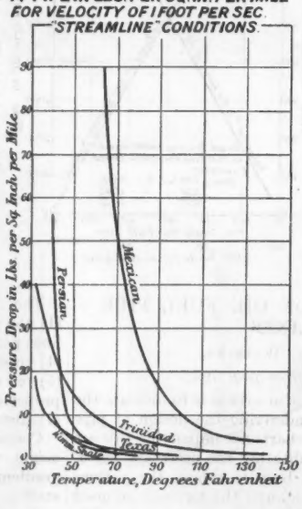


Fig. 12. OIL FUEL. PRESSURE DROP IN 14" PIPE. LOWER PORTION OF FIG. 11 ENLARGED

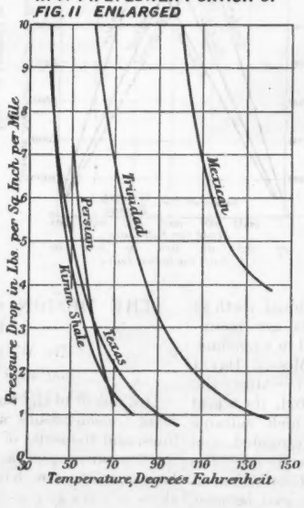
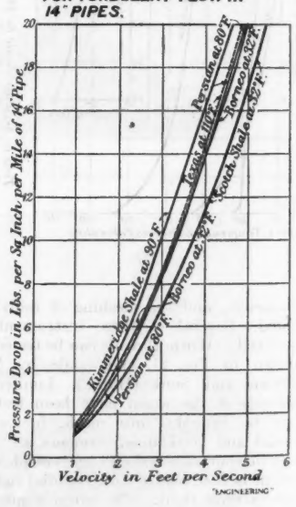


Fig. 13. OIL FUEL. PRESSURE DROP FOR TURBULENT FLOW IN 14" PIPES.


Pressure Drop in Lbs per Sq. Inch. per Mile of 14" Pipe
Persian at 80° F.
Texas at 80° F.
Borneo at 80° F.
Kimmeridge Shale at 80° F.
Persian at 80° F.
Borneo at 32° F.
South Shale at 32° F.
Velocity in Feet per Second
"ENGINEERING"

* It should be noted that for streamline conditions the value of "f" to be inserted in Formula A, can be read direct from the diagram, but for turbulent conditions the effect of the roughness of the pipe surface in contact with the oil has to be taken into consideration. For new pipes an addition of 10 to 20 per cent. will usually be sufficient, but for old pipes or badly aligned lines an addition of anything up to a maximum of 100 per

It is known that streamline flow in a fluid breaks down and becomes eddying or turbulent for a critical value of the velocity which makes the quantity $\frac{D\,v\,\sigma}{\mu}$ approximately equal to 2,500, and we give below, in tabular form, the critical velocities of flow in pipes from 6 in. to 16 in. diameter for values of $\frac{\sigma}{\mu}$ varying from 25 to 10,000.

Oil Fuel.

Critical Velocities in Pipes 6 in. to 16 in. Diameter.

Value of $\frac{\sigma}{\mu}$	Diameter of Pipe in Inches.					
	6	8	10	12	14	16
25	200·0	152·0	120·0	100·0	86·2	76·0
50	100·0	76·0	60·0	50·0	43·1	38·0
100	50·0	38·0	30·0	25·0	21·55	19·0
200	25·0	19·1	15·0	12·5	10·8	9·5
300	16·67	12·6	10·0	8·33	7·12	6·3
400	12·5	9·5	7·5	6·25	5·39	4·75
500	10·0	7·6	6·0	5·0	4·31	3·8
600	8·33	6·31	5·0	4·16	3·6	3·16
700	7·14	5·4	4·3	3·57	3·08	2·7
800	6·24	4·74	3·75	3·12	2·7	2·37
900	5·54	4·21	3·33	2·77	2·39	2·1
1,000	5·0	3·8	3·0	2·5	2·15	1·9
2,000	2·5	1·91	1·5	1·25	1·08	0·95
3,000	1·67	1·26	1·0	0·833	0·712	0·63
4,000	1·25	0·95	0·75	0·625	0·539	0·47
5,000	1·0	0·76	0·60	0·5	0·431	0·38
6,000	0·833	0·63	0·5	0·416	0·36	0·31
7,000	0·714	0·54	0·43	0·357	0·308	0·27
8,000	0·624	0·47	0·375	0·312	0·27	0·23
9,000	0·554	0·42	0·33	0·277	0·239	0·21
10,000	0·50	0·38	0·3	0·25	0·215	0·19

NOTE.—The "critical velocity" is the point at which the character of flow changes from "streamline" to "turbulent," and is expressed in feet per second.

Above table is calculated from $D v \frac{\sigma}{\mu} = 2{,}500$, where

D = Diameter of pipe in feet.
v = velocity in feet per second.
σ = density of oil in lbs. per cubic foot.
μ = absolute viscosity of oil in English units.

Of the remaining Figs., 10 to 12 inclusive, give the calculated pressure drops in lbs. per sq. in per mile of pipe line for pipes of 6 in. to 16 in. diameter under "streamline" conditions at a velocity of 1 ft. per second, from which the relative pressure drop at any other velocity which still maintains "streamline" flow may be calculated by simple multiplication, since for streamline conditions the pressure drop varies directly with the velocity.

For "turbulent" conditions Fig. 13 has been calculated for certain oils and velocities in 14 in. pipes up to about 5 ft. per second, but similar charts for other sizes may be easily prepared.

It may perhaps be of interest to point out that the results of calculation from the formula given herein, for the range of sizes selected (6 in. to 16 in. diameter) under streamline conditions do not appreciably differ from that obtained from the following approximations.

$P = \frac{\mu}{d^2}$ where P = pressure drop in lb. per sq. in. per ft. lin. when v = 1 ft. per sec.
d = Diameter of pipe in inches.

and $Pm = \frac{\mu \times 5280}{d^2}$ where Pm = press drop per mile, streamline flow, at velocity of 1 ft. per sec.

Simplifying these expressions we arrive at the following:—

$Pm = \mu$ 20·6 lb. per sq. in. in 16 in. pipes when v = 1 ft. per sec.
μ 27·0 lb. per sq. in. in 14 in. pipes when v = 1 ft. per sec.
μ 36·5 lb. per sq. in. in 12 in. pipes when v = 1 ft. per sec.
μ 52·8 lb. per sq. in. in 10 in. pipes when v = 1 ft. per sec.
μ 82·5 lb. per sq. in. in 8 in. pipes when v = 1 ft. per sec.
μ 146·67 lb. per sq. in. in 6 in. pipes when v = 1 ft. per sec.

This is an exceedingly useful series of approximations, since they enable a choice of size to be made, for preliminary design, that should be within a little of that finally decided upon.

(To be continued.)

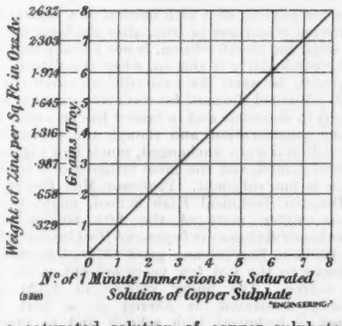
cent. may be necessary. Only experience and first hand knowledge of the condition in which the pipe line operates can assist the designer in this direction. It is usually better to calculate the P_m by inserting the value of f as read on diagram and then add the percentage increase to the P_m found.

METHODS OF TESTING GALVANISED IRON.

By SHERARD COWPER-COLES.

MUCH confusion prevails as to the relative value of zinc coatings applied to iron and steel by different methods, such as hot galvanising, electro-galvanising and sherardising. This uncertainty is largely due to the fact that many, if not most, of the published figures and reports give the results of corrosion tests without any figures as to the thickness of the zinc coatings. In hot galvanising the thickness of the zinc coating depends on the temperature of the bath, the fluxing and purity of the zinc, and the size of the crystals or spangles. In the case of electro-galvanising the thickness of zinc depends on time and current density, and in the case of sherardising on temperature, time and the condition of the zinc powder employed. Sheets hot galvanised by the original process carried about 2 oz. per square foot, but by the present methods employed the weight of zinc is reduced to 1½ oz. and even less. The thickness of the coating is, however, not the only thing to be considered. Much also depends on the physical condition of the zinc covering, whether it is porous, evenly distributed, free from impurities and from small blemishes or patches where the zinc has not taken.

The copper-sulphate test, also known as Preece's test, is still extensively used, although it is very unreliable and depends much on the manipulation. The test consists of dipping the zinc-coated steel



into a saturated solution of copper sulphate for 1 minute at 60 deg. F., and then washing under running water or wiping with a clean cloth; the 1-minute dippings are continued until the zinc is penetrated and a bright red deposit of copper obtained. The thickness of zinc coating is approximately determined from the number of dippings by means of the diagram above. The test is based on the fact that the copper precipitated on a zinc surface is a dark, loose powder, and on the iron or steel a bright-coloured deposit. The writer has seen this test carried out in large works under most unsatisfactory conditions, the same copper sulphate solution being used for a large number of immersions, instead of fresh solution for each immersion, and the test piece being wiped with a rag not free from grease; this gives an erroneous reading, as the slightest film of grease has a tendency to retard the action of the copper sulphate. This test is quite unreliable for zinc coatings applied by the electro or sherardising processes, as the deposits of zinc have a more or less matt surface, which holds some of the deposited copper, retarding the action of the copper sulphate in the subsequent dippings. A more simple and reliable method is to use a dilute solution of sulphuric acid. The strength of solution recommended by C. F. Burgess is 3·2 per cent. solution of pure sulphuric acid. As soon as the zinc coating is dissolved gasing ceases, thus enabling the evenness of the coating to be readily observed.

The salt spray test as devised by the Bureau of Standards, Washington, is a useful comparative test specially for ships' fittings, or galvanised iron work subjected to salt spray. The test is made in a stone box, with a cover, and glass supports for the samples. The stone box is inclined so that drops of solution collecting on the cover will run down to the edge instead of dripping on to the samples. The solution employed is 20 per cent. by weight of commercial sodium chloride (20 grammes of salt and 80 c.c. of water, or 2 lb. of salt and 1 gallon of water), with an air pressure of 6 lb. or 7 lb. per square inch, so that a very fine mist is produced. The compressed air is passed through glass wool or cotton plug, and then through water to remove any dust and to saturate the air with water vapour, which prevents concentration of the salt solution and crystallisation of the salt on the tips of the atomiser. A baffle plate is used to prevent the salt spray from blowing directly against the test pieces. The samples, after being washed to remove all grease, are placed in the spray box in a vertical position on the glass rod or strips. They are removed from the bath every 24 hours, washed with water, using a moderately stiff brush, and, after drying, are carefully examined for the presence of red or yellow iron rust. The first appearance of rust indicates the conclusion of the test; valuable information may be obtained by continuing the test and observing the extent of the corrosion produced by longer exposure.

Professor Walker has introduced a lead acetate test to determine the weight of zinc coating for a given area, the solution being composed of 3 lb. of commercial lead acetate in 1 gallon of distilled water, to which is added 1 oz. of litharge. The zinc is dissolved by immersion in the solution and the loss ascertained by weighing. Walker's soda test for porosity consists of placing the zinc-coated iron in a hot, strong solution of caustic soda; if the coating is perfect no gas is evolved, but if the iron or steel is exposed or there is any small hole or crack, a stream of hydrogen bubbles is evolved.

Mr. C. L. Campbell has devised a simple apparatus for measuring the amount of hydrogen generated from a known area of zinc coating, using a standard acid solution. A sharp maximum is reached in a few minutes, giving the resultant of all the different factors which make for rapid dissolution of the zinc, such as impurities in the zinc, cracks, or perforations. A modification of the method applied to sheets as described by Mr. A. S. Cushman, consists of attaching a ring and a small cylinder to the surface to be tested by means of modeller's clay or similar material. The cylinder is closed with a rubber cork, fitted so that strong hydrochloric acid can be run in with a little ammonium chloride to attack the exposed zinc. The resulting hydrogen is measured and the corresponding zinc calculated, the attacked area being measured by a planimeter.

For everyday works' practice the sulphuric acid test is probably the best, as giving both the thickness of zinc and evenness of distribution. In the case of electro-zincing the structure and quality of the zinc coating can be readily determined with a magnifying glass.

NOTES ON NEW BOOKS.

THERE are many aspects from which modern electric power practice may be viewed, but it comes rather as a surprise to find a book devoted to the description of circuit diagrams only. Such a book has, however, been published by The McGraw-Hill Publishing Company, Limited, London, entitled "*Electrical Machinery and Control Diagrams*," by Terrell Croft, price 15*s*. There are some 500 odd diagrams included in the volume, and it is claimed that they represent more or less completely all the apparatus which is used in modern electric power practice, with the exception of electric railways, telephone and lighting circuits. In the frontispiece are presented the standard electrical-diagram symbols which have been adopted by all the manufacturers who are members of the Electric Power Club of America, and these have been used throughout the book. In the first section of the book, diagrams of connections of both A.C. and D.C. generators are given; other divisions deal with the connections of transformers for various ratios of voltage and phase changes. Diagrams illustrating the various connections for rotary converters, motor generators, &c., are also given, including an example of an automatic substation. Only such supplementary text is added as is necessary to explain the diagrams. We find it difficult to believe that there can exist any large demand for a book of this description, but engineers requiring information of the kind will find almost every kind of diagram included in the volume.

We have several times (*vide*, our issues of December 8, 1916, and June 24, 1921) commended the volumes on "*A System of Physical Chemistry*," which Dr. William Mc.C. Lewis, M.A., Brunner Professor of Physical Chemistry, at Liverpool, has contributed to the Text-

Books of Physical Chemistry, edited by the late Sir William Ramsay and Professor F. G. Donnan, of University College. The third volume of the third edition of this work now before us [London: Longmans, Green & Co.; price 15*s.* net] deals exclusively with the "*Quantum Theory.*" Planck, when proving, in 1901, the impossibility of an equipartition of energy in the spectrum, had spoken of a "quantum hypothesis"; with the successful application of his conception of definite energy quanta to radiation, and subsequently to other physico-chemical phenomena the term "quantum theory" became general. Professor Lewis regards the theory as a new modified system of statistical mechanics. In Sir William Bragg's words, "Planck's hypothesis is not so much an attempt to explain as a focussing of all the difficulties into one so that, if this master difficulty is overcome, a number of others melt away." But the position of the quantum theory remains to a certain extent undefined, and the exact physical significance of the quantum of energy vague. When Professor H. A. Lorentz lectured on radiation last year (ENGINEERING, June 8, 1923, page 718) he exemplified the difficulties of the conception by a few numerical data. To produce interference a single quantum should have a length of at least 50 cm. and a diameter of 250 cm. or, with Michelson interferometer experiments, even of 5 m. One cannot visualise such a quantum. The consideration would further indicate that a quantum could not be concentrated, whilst if it were not, no single electron could absorb its energy in the way in which it was actually proved to absorb. For these and other reasons Lorentz, with other leading physicists, hopes for some interweaving of the undulatory and the corpuscular theories, and Professor Lewis, in this volume, examines recent researches primarily with the object of testing the validity of the quantum theory. The treatment thereby becomes less systematic and more detached than in his other volumes. The different sections stand indeed a little too much by themselves, not only in the appendices, in which the author, Mr. J. Rice, Mr. A. McKeown and Mr. R. O. Griffith, deal with definite researches of Einstein, Sommerfeld, Kratzer and others, but also in the chapters of the volume on the energy contents of solids and of gases, on atomic and molecular structure, on physical changes in homogeneous and heterogeneous systems and on the energetics of the ionic crystal lattice. A somewhat detached consideration of the quantum conception seems to be almost unavoidable at present. In his noteworthy second report of this spring to the Physical Society, Mr. J. H. Jeans only dealt with "Radiation and the Quantum Theory." On the other hand, most recent physical problems are admitted to have become less obscure by the application of the quantum theory; they ought to help to elucidate the nature of the quantum itself.

Much of the literature on impact problems is too mathematical for the engineer. The foundations of the laws were laid by Galileo and by Huygens; the recent better-known formulæ of Hertz are more frequently quoted than his paper on the contact between solid elastic bodies is read. The perusal of this paper—as of cognate papers—is indeed very difficult, or was so until Föppl's lectures on technical mechanics presented the subject in a simpler garb. The book by Dr.-Ing. Franz Berger, of Vienna, on "*Das Gesetz des Kraftverlaufs beim Stoss*" (Braunschweig: Friedr. Vieweg und Sohn; price 9 marks) is a theoretical and largely experimental study of impact phenomena, and does not restrict itself, as the title seems to indicate, to the energy relations. His colliding bodies are pairs of rigid pendulums swinging about the same axis, and he records their movements over scales by the aid of pointers and instantaneous spark photography. His formulæ express the duration of contact as a function of the velocity of impact and the deformation and distance traversed as functions of that velocity and of the time. His pendulums are fitted with elastic buffers, and he likens a colliding body and its molecules to a railway train, the carriages of which are so coupled that the elastic buffers always remain in contact. When an engine crashes into such a train simply with its mass energy, the phenomena are those of pure impact. When the engine is further propelled by steam, the impact becomes complex.

The literature on blast furnaces giving the result of the experience of British technical men, all actual makers of pig iron, and dealing both with the theory and with the practice of economical iron manufacture, is very detailed and complete. The very first paper in the proceedings of the Iron and Steel Institute was one by Sir Lowthian Bell, on "The Development of Heat and its Appropriation in Blast Furnaces of Different Dimensions," read in 1869. This and subsequent works on the subject by many specialists have always been considered as constituting standard works. Among the more recent papers on blast furnaces, read and discussed before the Institute, we may mention the one by Clements on "British Blast Furnace Practice," read in 1920, and that by A. K. Reese, on "The Bases of Modern Blast Furnace Practice," contributed in 1922. None of these important contributions is referred to in "*Combustion in the Gas Producer and the Blast Furnace: A New Theory,*" by Dr. A. Korevaar, lecturer in industrial chemistry at the University of Leiden, Holland, a book recently issued by Messrs. Crosby, Lockwood and Son, London (price 15*s.* net). The economical manufacture of pig iron has been of late years greatly hampered by the increase in the impurities found in the coke, the ash content probably playing the greater part; impurities in the iron-stone have also contributed much in complicating the ironmaker's task. Owing to these impurities many well thought-out theories must fall to the ground. In his book, the author develops a new theory of combustion, leading to the formulation of the law of "heat compression," and by "heat compression" the author means obtaining in the furnace conditions resulting in the zone of combustion having a smaller volume and a higher temperature. His theory shows that when such conditions are reached in a furnace he can produce a higher temperature with equal fuel consumption, or conversely, produce a definite temperature with a lower fuel consumption. He then states: "The importance of this theory is that it shows that the fuel economy gained by means of better combustible fuel, hot blast and the other factors dominating combustion is all due to the law of "heat compression," which is at the bottom of all the different ways of diminishing fuel consumption. This was quite unknown to the present day." The author has given a very clear exposition of his deductions. His book will no doubt be read with interest by British manufacturers, whose expressions of opinion concerning it would probably prove interesting.

The compilation of a fifth edition of a textbook on engineering structures in iron, after the lapse of many years since the fourth edition, is not an easy matter as a rule; particularly is this so, when the fifteen years intervening between the two editions cover the war period. Much of the need for war structures has gone; economy in materials and in labour has become a more pressing consideration, and though the principles of construction remain unchanged, much new experience has been gained, and the mere bringing of a book up-to-date is not sufficient. Professor Max Foerster, of the Dresden Technical High School, might perhaps have re-written more of the fifth edition of his "*Eisenkonstruktionen der Ingenieur-Hochbauten*" [Leipzig: Wilhelm Engelmann; price 45 gold marks], but references to the last few years are not on the other hand scarce. The bulky volume of 1,320 pages copiously illustrated, is offered as a text book for use at technical high schools and in practical engineering, and as a supplement to the Handbuch der Ingenieurwissenschaften. It deals with steel as a material, and with riveting and bolting; with columns and girders, and in particular with roof structures, frame work and stairways. A good feature of the treatment is that examples are worked out.

The material advantages to be secured by the adoption of well-devised schemes for town building and extension, to which it is convenient to apply the term "Town-planning," are admitted on all hands. The creation of healthful homes, ample open spaces in parks and playgrounds, the preservation of amenities of site, and the provision of a system that secures adequate and economical transport, will have the approval of all, rendering the advocacy of proposals directed to these ends unnecessary. But that is not the view of Mr. H. V. Lanchester, who, in "*Talks on Town Planning,*" (London: Jonathan Cape, price 4*s.* 6*d.*) appears to be forcing an open door. His object, if correctly understood, is not to exhibit the details of a proposed scheme, to demonstrate how approved suggestions may be carried out practically, or to indicate the means for providing all the necessary machinery for substituting a new system that will displace the errors of the past, but apparently to urge on the public the desire for creating improved and agreeable surroundings. He would present such an enticing picture of the science of town planning that new disciples will be found, eager to claim the realisation of far-reaching schemes, plausibly and ably urged. The arguments are enforced or illustrated in a series of imaginary conversations, which seems a rather clumsy way of calling attention to his views. The *dramatis personæ* include a man in business, whose part is to put the questions that the author wishes to answer through the mouth of a professor of History and Sociology: a mechanical engineer who may be supposed to represent the practical side in the debates, and an artist, who may be regarded as a supporter of æsthetics. These four discuss many things besides town planning, and when the cloven hoof of Communism appears rather near the surface, the Professor, who does most of the talking, thinks it necessary to declare his faith by asserting that "he is not out for land nationalisation," and claims that while he "does not make a god of property, it does not seem necessary at the moment to go for anything like confiscation." The book is not uninteresting, since it gives the views of one who has thought much of the matter, who places communal interests far above private enterprise, and would remodel our towns by improving the methods of the past.

The growing scarcity of lumber in most European countries has not resulted in driving the destructive distillation of wood to the other continents, but rather has obliged the distiller to perfect his methods, and to utilise his products to the fullest extent. The old charcoal burner would feel bewildered in a modern wood distillery, where the charcoal is indeed the bulkiest but by no means the most valuable product. The latter comprise acetone, acetates and acetic acid, ether, methyl alcohol and formaldehyde, &c. The formaldehyde in particular has acquired considerable importance of late as raw a material used in the preparation of various insulating materials. To produce these compounds requires competent engineers and chemists, all the more as the difficulties of the collection and transportation of the raw material frequently lead to the erection of the factories in remote districts. Mr. G. Dupont, Professor at Bordeaux, has brought the subject, which had been somewhat neglected by authors of late, up to date in his small volume on "*Distillation du Bois*" (Paris: Gauthier-Villars & Cie; price 25 francs). He is connected with the Institut du Pin, in connection with which he has been lecturing on wood distillation to chemists and engineers. He gives notes on the uses of the products, but does not, of course, deal at length with the many condensation products of formaldehyde.

So many advances and refinements have now been made in the methods of workshop measurement that the subject is one which demands a more extended treatment than that which is summarily allotted to it in books dealing with machine shop practice. The war was a great awakener and quickening force in all that concerned systems of gauging, because parts of munitions had to be distributed among many shops, separated by hundreds of miles, and prepared for assembly without correction. It was then that gauging systems were introduced in many shops for the first time. The habit, once acquired, became established. It is now common for components to be prepared in a finished condition in several independent plants, all contributory to the final assembling. This can only be accomplished by the help of proper gauging systems. The subject has now become so wide, and so many different types of apparatus are concerned, that the average shopman may at times find it difficult to keep properly in touch with the subject. To such men "*Workshop Gauges and Measuring Appliances,*" by L. Burn, A.M.I.Mech.E., A.M.I.E.E. (Sir Isaac Pitman & Sons, Ltd.; price 5*s.*), should appeal. Though modestly offered to apprentices and students, it will prove of value to all who are interested in the subject of which it treats. Not the least of its recommendations is that it is a handy book of reference, containing tables—20 in number—that relate to standards of measurement, gauges, and limits. It is a useful book to be kept on the desk for ready reference. The book contains seven chapters, commencing with units of measurement and terminating with limits and fits. Some of the later refinements in measurement—those of screw threads chiefly—are not described, but the subjects that are treated are dealt with in a satisfactory manner.

A NEW LIQUID ENAMEL.—According to an article published in *Chemical and Metallurgical Engineering* the American Dupont Company are introducing a new enamel which can be applied cold, and is claimed to give results equal in appearance to stoved enamels. The material, which has been called Duco enamel, has a nitrocellulose base, and is so fluid at ordinary temperatures that it can be sprayed on the surfaces to be treated by the ordinary pneumatic sprayers. The special characteristic of this enamel is that the nitration of the cellulose is kept between 11 per cent. and 11·8 per cent. If these limits are exceeded the product becomes too viscous for convenient use.

USES OF COBALT.—In a paper read before the Société des Ingénieurs Civils in Paris, M. L. Guillet stated that the addition of cobalt to steel and other metals in no way improved their mechanical qualities, but rather the reverse. On the other hand, cobalt magnet steels which contained from 10 per cent. to 40 per cent. of the metal, with a little tungsten or chromium, or both, were three times as good as the best ordinary magnet steels. It was claimed that an addition of 3 per cent. to 5 per cent. of cobalt to high-speed tool steels was an advantage, but the claim was not universally accepted. Cobalt plating was much superior to nickel plating. The baths could be more concentrated, and heavier currents employed, so that good coatings could be obtained in a few minutes.

AUTOMATIC ELECTRIC BUTT-WELDING MACHINE.

AUTOMATIC ELECTRIC BUTT-WELDING MACHINE.

CONSTRUCTED BY THE A.1. ELECTRIC WELDING APPLIANCES COMPANY, ENGINEERS, LONDON.

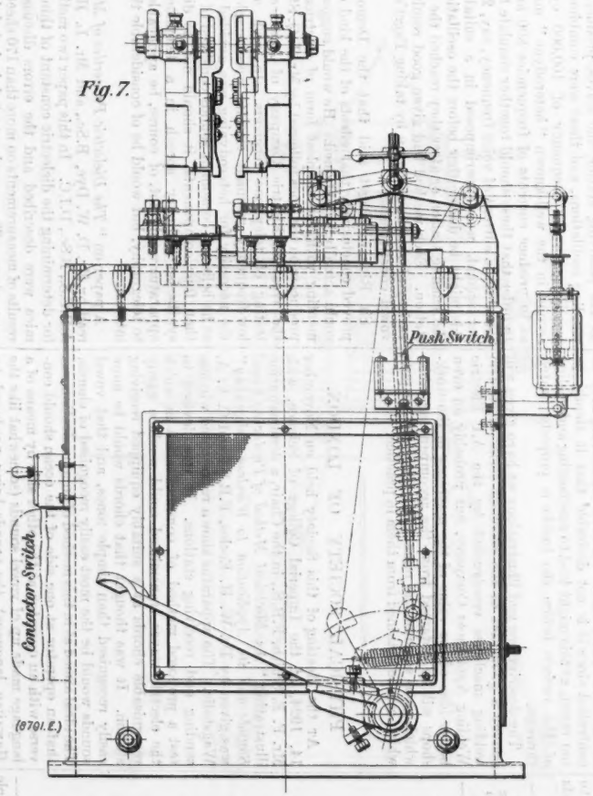


Fig. 7.

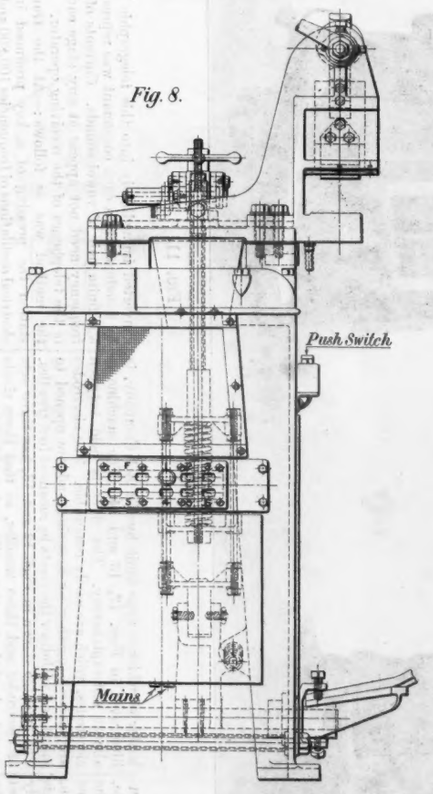


Fig. 8.

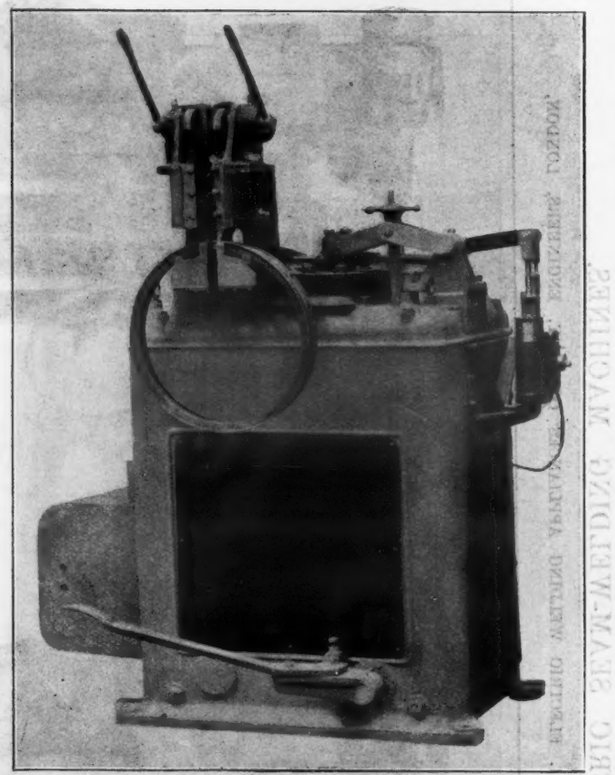


FIG. 9.

THE A.1. ELECTRIC WELDERS.

(*Concluded from page* 765.)

ALTHOUGH spot welders have a very large field of usefulness they cannot deal with every class of work, and when material has to be joined end-on a butt welder has to be used. An example of one of the machines of this type built by the A.1. Electric Welding Appliances Company is illustrated in Figs. 7 to 9 on this page. This machine is automatic and is capable of welding bars, tubes, cycle wheels, rims, &c., end-on, very rapidly and with remarkable neatness and strength. The machine consists of a cast-iron main frame, carrying the transformer and having mounted on its upper side two work clamps, which hold the job being dealt with. One clamp is fixed while the other can slide and is controlled by a toggle and dash-pot lever. The method of holding the work is clearly seen in Fig. 9, which shows a wheel rim in process of being butt welded. The job is placed in position on the lower blocks and secured by the upper clamps, which are operated by the cams and hand-lever shown. The lower blocks, which are water-cooled, form the secondary terminals of the transformer. When the work is in place the foot treadle is depressed. This movement first switches on the current to the transformer and the parts to be welded are brought together by the action of the lever and toggle mechanism, which can be best seen in Fig. 7. The secondary circuit is, of course, made immediately the parts come into contact.

The toggle and dash-pot mechanism which can be seen in Fig. 7 form a special feature of the machine, and is patented. As will be clear from this figure, depression of the treadle straightens out the toggle and moves the sliding head of the machine to the left, bringing the parts to be welded into contact. The same action, however, depresses the plunger of the dash-pot which tends momentarily to check the motion. The result of the arrangement is that although the operator depresses the pedal rapidly, the parts to be welded move together at a speed predetermined by the adjustment of the dashpot valve. As will be seen, the mechanism is provided with various adjustments, so that it can be set to suit a large variety of jobs.

A further valuable type of machine—the seam welder—is represented by two examples shown in Figs. 10 and 11, page 828.

Seam welding consists of welding together the overlapped edges of two sheets of metal by local electric heating under pressure, with copper rollers or wheels. The combined effect of the pressure and heat causes the seam to be welded, to unite in a homogeneous manner. Seam welding is a development of spot welding, and is more suitable for some purposes where a tight joint is desired. It is, however, limited in its application to thinner material; and aluminium cannot be seam-welded. The machines are of a similar type to the spot welders, with rollers substituted for the electrodes. The upper roller-electrode is power-driven. The lower roller is driven by friction for thin stock, but for heavier thicknesses both rollers are driven. The design of the machine includes a coned pulley to give varied speeds, which pulley should be belted to the main shaft, or to a small motor, as may be desired. There is an instantaneous clutch so that the machine can be stopped and started at will. Material should be reasonably clean on the welding edges, and there should be no grease, paint or, above all, scale.

The method of procedure is as follows:—The two sheets to be welded are overlapped, usually one-sixteenth of an inch, though in thick sheets up to ¼ in. is sometimes desirable. The overlapping edges are then placed with the start of the joint under the electrode, and the pedal is depressed. This makes a spot weld at the starting-point. This operation is repeated at suitable distances, say, every 6-in. along the line to be welded. This is called tacking. Then, starting again at the beginning, the edge of the seam to be welded is fed between the rollers. The pedal is next depressed and kept thus so that the revolving electrode rollers are kept in contact continuously, and the sheets guided in so that the seam is kept between the rollers as it is automatically fed in, or drawn in by the action of the driving roller or rollers and pressure. The pedal is released the instant

ELECTRIC SEAM-WELDING MACHINES.

CONSTRUCTED BY THE A.1. ELECTRIC WELDING APPLIANCES COMPANY, ENGINEERS, LONDON,

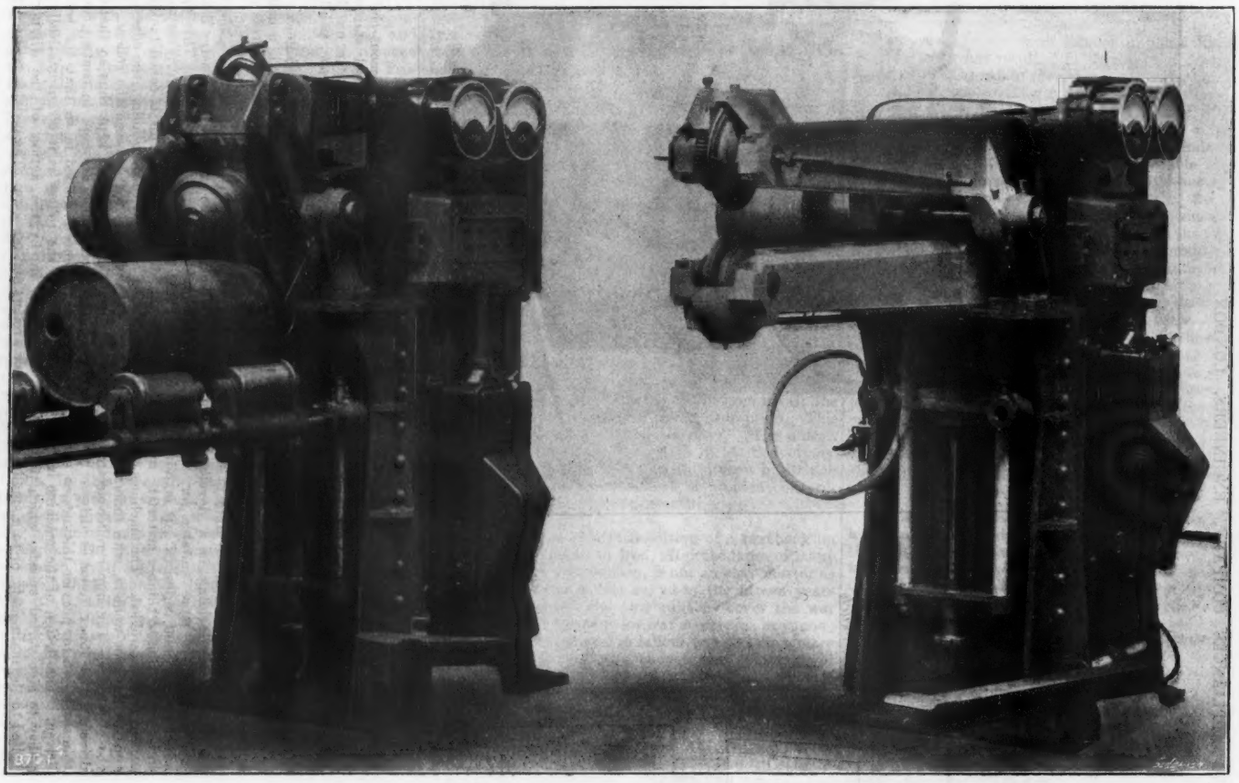


Fig. 10.

Fig. 11.

the end of the seam is reached. The weld is then complete. From 2 ft. to 10 ft. can be welded per minute. The outstanding feature of the machine is that the heating of the weld is intermittent, effected by means of an arrangement of two coils of separate alternation, the secondary windings being in series. By this means the duration of welding heating can be accurately controlled at any point. The arrangement is patented and permits of a wide variation and control in the rate of heating by the current and the intervals between successive periods of heating. Tests up to 600 lb. per square inch have been stood by welds of seam-welded drums.

Description of Work.	Welds per Hour.	Welds per B.O.T.U.	Actual Welding Time in Secs.
			Secs.
Corner weld for steel sashes	120	80	4
Knife blade, stainless steel, butt welded to shank ..	240	60	3
Cycle rim section, butt welded	300	150	3
Motor cycle belt rim, butt weld	80	120	4
Copper bars and steel rod welded to hardened steel block without drawing the temper	200	160	2
Mild steel bar, 2½ in. by ¾ in. T welded to mild steel bar, 1½ in. diameter..	80	30	5
C.I. valve head, welded to special steel stem.. ..	80	30	4
M.S. bar, ¾ in. diameter, welded to the edges of mild steel bar, 2½ in. by ¾ in.	120	60	6
Wire mesh guard, spot welded to 1 in. by ¼ in. M.S. strip	250	120	3
Rivets heated and closed in ball bearing cage	360	600	1
H.S. steel lathe tool welded to M.S. shank	80	30	4
Spot weld, ¾ in. added thickness	60	15	8
Motor car tyre rim butt welded	120	40	5

An interesting and useful extension of the principle of electric welding is afforded by the electric rivet heater of which a type built by the A.1 Company, is illustrated in Figs. 12, 13 and 14. The machine is almost self-explanatory. The rivet is held between electrodes, which are easily renewable. The electrodes are pressed together by a spring and are opened to insert and withdraw the rivets by means of foot treadles. The machine shown in Figs. 12 and 13, has three sets of electrodes and three treadles, so that three rivets may be heated at a time. That shown in Fig. 14 is intended for two rivets. The rate of heating may be controlled since it is not desirable that it should be too rapid, as this might lead to overheating and scaling of the surface before the inside is properly heated through.

The descriptions and illustrations we have given will convey a good idea of the excellent series of electric welding machines constructed by the A.1 Electric Welding Appliances Company, but probably an even better idea of the value of the machines in the workshops will be obtained from the accompanying table, which gives some of the remarkable times and outputs which can be obtained from them in practice.

PHYSICAL SOCIETY OF LONDON.

At the Meeting of this Society held on November 14, 1924, at the Imperial College of Science, with Mr. F. E. Smith, F.R.S., in the Chair, a demonstration illustrating "*An Electrical Method of Producing Vowel Sounds and its Application to Wireless Telegraphy*" was given by Dr. W. H. Eccles, F.R.S., and C. F. A. Wagstaffe. The apparatus shown represented wireless sending and receiving stations. It was devised to test a proposed method of communication in which the electric waves transmitted could produce easily recognisable chords at a suitably equipped receiving station. It was thought that chords would be more easily recognised than simple tones, and that vowel sounds would be the most easily recognised of chords. The ideal aimed at in this method of communication was that an operator at one side of the ocean should converse with an operator at the other side by means of a language made up of vowel sounds (somewhat like the Hawaiian language), the sounds being produced by pressing keys. Any ordinary language could be converted immediately into this telegraphic language by a code wherein each consonant was represented by a definite pair of vowel sounds. Currents of acoustic frequency need not appear at any stage earlier than in the telephones of the receiving operator. Broadly, the method was as follows:—At the transmitting station the pressing of a key produced immediate electrical oscillations of frequencies 100,800 and 101,300, and waves of these two frequencies were radiated. At the receiving station the waves produced corresponding oscillations, and these were combined with a locally generated frequency of 100,000 cycles per second in the well-known "heterodyne" manner, so as to produce currents of frequencies 800 and 1,300. In order that these should together simulate the vowel sound *ah*, a current of voice frequency, say, 250 cycles per second, was superimposed in a suitable way; this might be done either before the oscillations leave the sending station or after they reached the receiving station. Each method had given good results with a variety of vowels, made up by taking Paget's table of vowel constituents.

Sir Richard Paget said that the Demonstration proved conclusively that effects of the kind described could actually be obtained. He would suggest experimenting with the simplest form of electrical sound-producers on the lines followed by Mr. J. Q. Stewart, of the Western Electric Company of America, in the testing of telephone receivers. In such apparatus low-frequency resonant circuits were employed and the necessity for heterodyning was avoided; and if, as he believed, consonant sounds consisted of not more than four components, it should not be difficult to synthesise ordinary speech in a telephone. Such apparatus would not, of course, be applicable directly to telegraphy, but would be of considerable theoretical interest.

A paper on "*The Dielectric Properties of Mica*" was read by Mr. D. W. Dye, B.Sc., and Mr. L. Hartshorn, A.R.C.S., B.Sc., D.I.C. In this paper two methods used for determining the dielectric constant of thin sheets of mica were described and the errors discussed. The results of measurements on more than 170 sheets of mica were given. The samples tested included best clear mica, ruby, green and brown in colour, stained and

ELECTRIC RIVET HEATER.

CONSTRUCTED BY THE A.1. ELECTRIC WELDING APPLIANCES COMPANY, ENGINEERS, LONDON.

(*For Description, see Opposite Page.*)

Fig. 12.

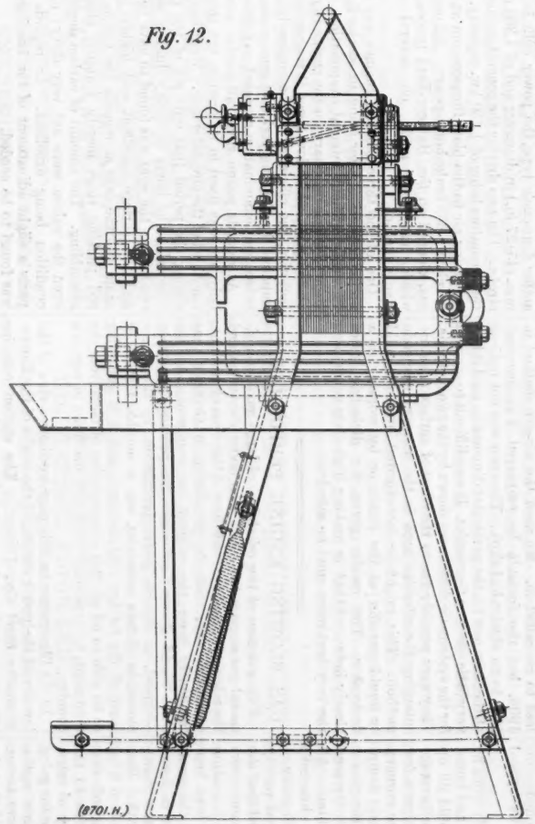
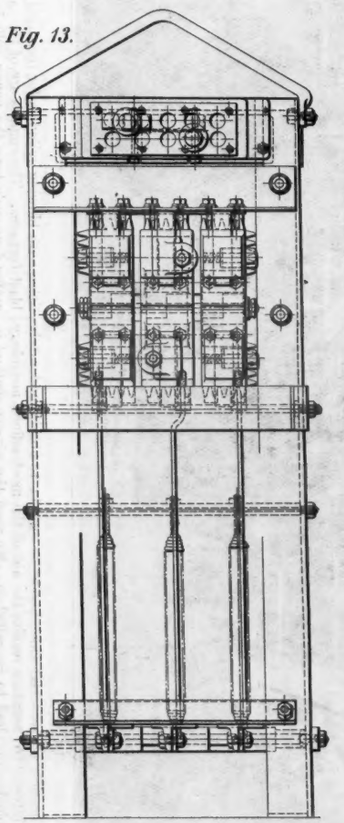


Fig. 13.



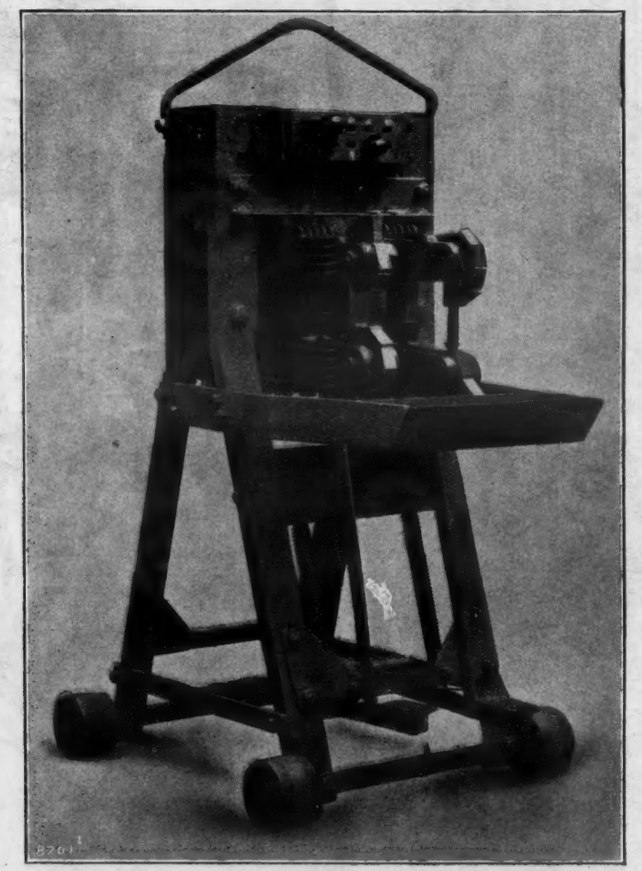


FIG. 14.

spotted samples, and also samples with gaseous inclusions. There were also samples of amber mica and silver amber mica. The results show that practically all samples of muscovite (potassium mica) had the same dielectric constant, the most probable value being 7·0. The presence of inclusions had no great effect on this value. The samples of phlogopite (magnesium mica)—*i.e.*, the amber micas—had rather lower dielectric constants, about 6·0 for normal amber mica, and 5·0 for the silver amber variety. Values of power factor were given for many of the samples. For the clear micas (muscovite) it might be as low as 0·0003, and possibly less. The effect of inclusions was to increase it considerably. The power factor of the amber micas was greater than that of the muscovite variety—about 0·02 for the clear amber and 0·05 for the silver amber variety. The samples were all about 8 cm. square and 0·1 mm. thick, and the measurements were all made on the Carey Foster bridge at a frequency of 800 cycles per second.

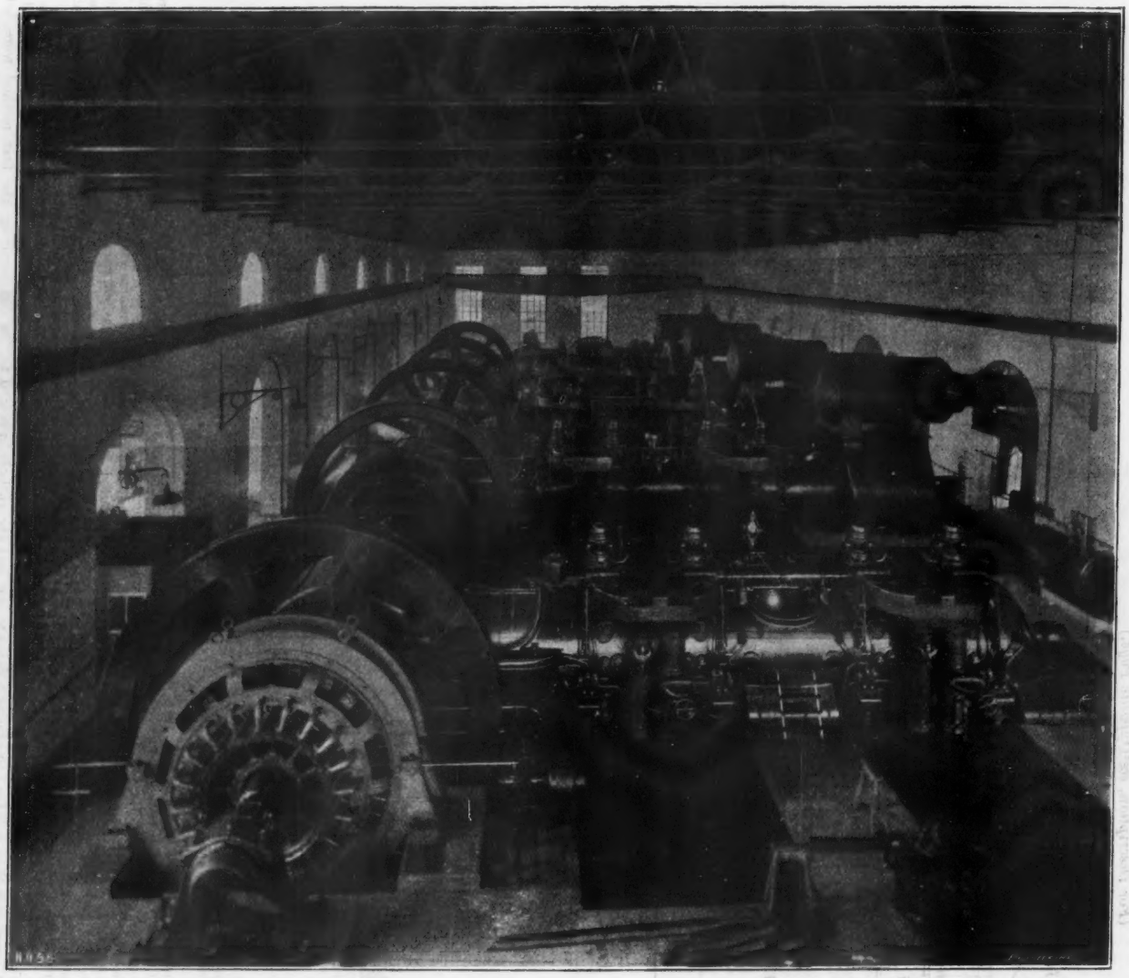
Mr. P. R. Coursey pointed out that the variation in the specific inductive capacity of different samples of mica of the same type was as great as the variation between samples of different types, and said these variations were perhaps to be accounted for by the fact that the thickness as measured might include the thickness of layers of included substances in addition to the mica. This view was confirmed by comparing an optical measurement of the thickness (by means of polarised light) with a mechanical measurement, when a considerable discrepancy was found. A paper published some years ago in the Physical Review gave a large number of results rather greater than 8·0 for K; possibly, the lower values found by the authors might be attributable to inclusions. It was known that there were oil inclusions in the mica commonly employed for commutator rings, and, of course, in such cases it was the actual specific inductive capacity of the impure mica that was of practical importance. The power factor must be attributed to laminæ of imperfectly insulating impurities, and in commercial samples the power factor became serious at radio-frequencies, when the apparent specific inductive capacity might drop to about 3.

Mr. F. E. Smith said that the air-gap method appealed to him as a delicate one, but the authors appeared to prefer the mercury-electrode method. He would suggest that the results of the latter might be vitiated by the fact that the actual area of contact of the mercury with the mica was not the same as the area of the exposed portion of the mica, in consequence of the meniscus effect. The cleaner the mercury the more marked would this discrepancy be, and the error in diameter arising from this cause might well amount to 1 mm., which would account for the 6 per cent. difference between the results of the two methods. He would suggest trying the effect of compressing the mercury.

Dr. D. Owen said that such limitations of accuracy as did occur in the first method were, admittedly, imposed by the extremely small thickness of the specimens; and this notwithstanding the special care taken in planing and paralleling the metal plates

GAS BLOWING ENGINES AT THE BARROW HEMATITE STEEL COMPANY'S WORKS.

CONSTRUCTED BY MESSRS. GALLOWAYS, LIMITED, ENGINEERS, MANCHESTER.



bounding the air-gap. In regard to the question of uniformity of the specimens, it would be of interest to know whether the particles of possible foreign inclusions were large enough to be put in evidence by optical tests.

Mr. G. L. Addenbrooke said that in his early work he had had some trouble with air bubbles, but had found that, under a pressure of 2 in., mercury would fill up any corner. He personally had used an average pressure of 4 in. or 5 in., and given the container a few sharp knocks to shake the mercury into the corners. Was the mica used by the authors dry? Any dampness would have a considerable effect on the power factor. Under a microscope mica was distinctly seen to be laminated, and it might contain air films. All such points were, however, of subsidiary interest; it was particularly interesting to see the uniformity of the results obtained by the authors for a great variety of specimens, because he had always suspected that the lack of uniformity in the behaviour of mica condensers was to be attributed to other causes than variation of the specific inductive capacity; he had been kept back from pressing this view publicly by the great variation to be found in the values given in tables of physical constants, a variation which was now shown to be erroneous. It was worth mentioning that Post Office engineers assumed an all-round value of 6·6 for the purpose of their specifications. He hoped that the paper, besides clearing up the doubt as to the constancy of the specific inductive capacity of mica, would call attention to the general necessity for going over the accepted values of such constants again. Existing tables took no account of the power factor.

Mr. A. Campbell, in a communication, said that the paper removed most of the uncertainty which existed regarding the dielectric constant of mica. One of the main difficulties lay in the very small thickness of the material which had to be tested; to obtain moderately accurate results the aid of the most refined metrology had to be called in. He used the air-gap method in 1906, but the formula he employed was incorrect (due to an algebraical slip). The error was not noticed at the time, as with the particular dimensions used it had very little effect on the results. It was difficult to account for the systematic differences shown by the two methods. They were possibly due to the effect of surface moisture enlarging the effective area in the mercury electrode method. This might be investigated by using solid or liquid paraffin at the joints or by working in a desiccator. The results given for dielectric losses clearly indicated that in making high-class condensers the very best mica must be selected.

GAS BLOWING ENGINE PERFORMANCE.

THE question of the reliability of large modern horizontal gas engines has often been under discussion and the relatively small use made here of this class of machine, compared, say, with its popularity in Germany has frequently been the subject for comment. At the First World Power Conference the prominent position occupied, as regards power production, by this prime mover, in certain countries, was a notable feature of some of the foreign contributions, and it is gratifying to be able to off-set this accumulation of facts from the Continent, by experience with such machines in our own country.

In the illustration on this page we show a view of the interior of the power station of the works of the Barrow Hæmatite Steel Co., Limited. The station contains altogether six large horizontal slow-speed gas engines, of which five were built by Messrs. Galloways, Limited, of Manchester. Two of the five are coupled direct to direct current generators, while the other three are fitted with blowing cylinders for the supply of air to the blast furnaces. The engines are of the tandem double-acting four-cycle type, the power cylinders being 1,150 mm. (45·27 in.) in diameter and of 1,300 mm. (51·2 in.) stroke. The two driving the generators run at 94 r.p.m., the generators being of 1,250 kw. capacity. The engines supplying air to the blast furnaces run at 85 r.p.m. and develops 1,650 brake horse-power. All use blast furnace gas, cleaned on the Halberg-Beth process, reference to which has been made on several occasions in ENGINEERING.

One of the three blowing engines was lately opened up for inspection, after being in service for no less than 77 weeks without internal examination. Before being stopped it was necessary for the engine to run for a while at 25 r.p.m., which low speed it maintained quite satisfactorily, the efficiency of the engine being in no way impaired by the long period of service mentioned. The subsequent examination revealed no evidence of defects.

As regards piston rings, all twelve were intact, and only one was fixed in its groove, but this one for only one-third of the circumference. Wear had been so slight during the period that only six of the rings required renewal The liners of both cylinders were in perfect condition; the wear was found to have been very small, and the surface excellent and highly polished. The same was the case as regards the piston rods, and the rod packing rings merely required cleaning and re-assembling. The amount of carbon deposit was small; even the valves were not very dirty; otherwise their condition being excellent. As regards the working parts a slight adjustment of the bearings was all that was found to be needed.

Another of the blowing engines had, at the time of the laying off of the engine above referred to, completed some 75 weeks of service without being stopped for examination. As a result of the excellent condition of the one

inspected, it has been decided to extend considerably the period for the second, which is consequently not being laid off at present. These long periods of service and the excellent state of conditions revealed, are eloquent testimony as regards the reliability of this type of machine when well constructed, and well run.

LETTERS TO THE EDITOR.

SKIN FRICTION IN AERONAUTICS.

TO THE EDITOR OF ENGINEERING.

SIR,—With reference to your article "Skin Friction in Aeronautics" (ENGINEERING, November 28, page 742), relating to the paper read by Professor Bairstow at the Royal Aeronautical Society on Thursday, November 13, may we be allowed to make some remarks on the statement that in the experiments carried out at the Aerodynamical Laboratory of the Delft Technical High School a glass plate was used with a *rounded* leading edge.

As Professor Prandtl has already mentioned ("Ergebnisse der Aerodynamischen Versuchsanstalt zu Göttingen I," page 136, footnote), a plane surface with a rounded leading edge will give rise to the turbulent state of motion in the first part of the boundary layer; great care was taken in the experiments referred to to sharpen the leading edge of our glass plate as well as possible, and thus to avoid the turbulence in the first part of the boundary layer. This was done by grinding and polishing the plate to the form shown in the accompanying figure.

The effect of various forms of the leading edge was studied, and it was found that the shape used in the experiments was highly satisfactory. At low values of Reynolds' number a good agreement with the theory of Blasius was found, but once the critical value of R was passed, turbulence set in. This experimentally determined critical value proved to be higher than one would expect from the experiments on the resistance of the flow through tubes, which leads to the supposition that the leading edge of our glass plate cannot have had much influence on the flow in the first part of the boundary layer.

The lateral spreading of the air in the neighbourhood of the glass plate was investigated by determining the velocity distribution in the channel by means of a Pitot tube, 15 cm. behind the glass plate; no trace of lateral flow could be detected. Moreover, the velocity distribution in the boundary layer was measured at the middle of the height of the glass plate, 150 cm. from the leading edge, and also 15 cm. above; both velocity curves obtained in this way were identical, the mutual differences between the values of the velocity of the air at equal distance from the surface did not exceed 1 per cent. As Mr. Southwell has already remarked, this can be explained by the suspension of the plate in the channel; as a simple calculation had shown, the air could in our case find no way with less resistance than along the plate. Therefore, we were led to suppose that lateral spreading is not involved.

The pressure drop along the glass plate was determined separately by means of a Pitot tube; as expected the velocity of the air outside of the boundary layer along the plate was higher when the distance from the leading edge was greater. In the evaluation of the experimental results this effect was taken into account and a fair agreement between the resistance of the glass plate calculated from the known velocity gradient at the surface and from the loss of momentum in the boundary layer was obtained in this way.

Yours faithfully,

B. G. v. D. HEGGE ZYNEN.

[NOTE.—We regret that in commenting on Professor Bairstow's paper we did not define the shape of the leading edge of the glass plate referred to more accurately. The dimensions given by Professor Bairstow in the paper itself are in exact agreement with those reproduced on the sketch above, which should remove any misunderstanding as to the shape of the leading edge which may have arisen from our reference to it as "rounded."—ED. E.]

LONDON UNIVERSITY B.Sc. DEGREES IN ENGINEERING.

TO THE EDITOR OF ENGINEERING.

SIR,—It would appear desirable that candidates for the above who enter for Honours and are not successful in obtaining them, but who reach such a standard as to be recommended by the Examiners for a Pass degree, should be permitted, if they so desire, to sit at any subsequent examination as ordinary candidates, with a view to obtaining Honours. The difference in outside life between the value of an Honours and that of an ordinary Pass degree is very great, and it appears hardly fair that an Honours candidate should, on account of his having been recommended by the Examiners for a simple Pass, be penalised by being for ever afterwards debarred from trying to obtain Honours. If it is not considered practicable to allow the Pass degree to be awarded to Honours candidates on the understanding that such candidates may afterwards try as often as they please to obtain Honours, it would appear that the candidates should at least be given the option of refusing acceptance of the Pass degrees for which they have been recommended. In this way they might retain the right to try again, as often as they choose, to obtain Honours.

The matter is one of considerable importance, especially as the majority of the graduates (at any rate amongst the External men) will not proceed beyond the B.Sc. degree, and would be satisfied with that degree if Honours could be obtained. I feel that a welcome change for Honours candidates in the Regulations would be one that would enable the candidates either (*a*) to accept and retain the Pass degree, with freedom to try at any time subsequently for Honours under the same conditions that would exist if they did not already hold the Pass degree, or (*b*) definitely to refuse acceptance of the Pass degree which might perhaps be offered on each occasion to an Honours candidate who reached the Pass, but not the Honours standard. If a candidate finally decided (perhaps after several unsuccessful attempts to attain Honours, followed possibly by refusals of a Pass) to accept a Pass recommended by the Examiners, then his decision might be held to be irrevocable. In this case the degree would date from the year of acceptance, the candidate's previous refusals of a Pass definitely ruling out the earlier dates.

An advantage in allowing a student re-entry to the examination, under either of the two alternatives mentioned, is that he would retain the incentive to work. The qualification of Honours would, in general, be of much greater value to him in many ways than a mere Pass. In fact, the possession of the latter, with all hope of a higher B.Sc. success permanently withheld, would probably put a stop to the further studies of many ordinarily earnest and ambitious students. In certain professions, such as, for example, teaching, the permanent possession of a Pass B.Sc. degree in Engineering, with no hope of being allowed to take Honours, might well prejudice the prospects of the holder as compared with those of others who have managed to obtain Honours. Such a person may see students pass their Matriculation and Intermediate examinations and then proceed to take Honours at the Final, whilst he himself has, of necessity, to sit idly by because he cannot, being saddled with the Pass recommended by the Examiners when he attempted Honours, again enter the examination in an effort to obtain Honours.

Apart from the question of re-entry to the examination as it affects Honours candidates who have been recommended for a Pass, I see nothing against all Pass degree men, even those who entered the examination as candidates for a Pass and not an Honours degree, being allowed as many re-entries to the examinations as they care to make, subsequent to obtaining the Pass degree, in an attempt to obtain Honours. A man may have taken a Pass degree in order to obtain a University qualification at the earliest possible moment. Such a man may afterwards study and perform such work as will give him a reasonable hope of being able to pass with Honours. It is difficult to imagine that any harm would be done even if he failed at the examination, whereas if he succeeded his prospects in life might thereby be greatly improved.

Yours faithfully,

PRACTICE AND THEORY.

London, December 13.

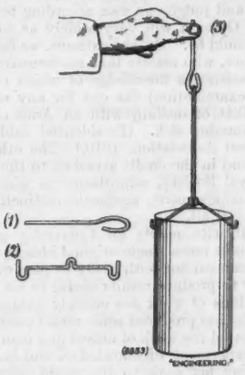
THE FLETTNER ROTOR SHIP.

TO THE EDITOR OF ENGINEERING.

Sir,—The circulation principle of fluid reaction, as applied to wings and to the Flettner "rotor" ship, may be demonstrated very simply and convincingly by a modification of the Robin's pendulum, exhibited by Benjamin Robins, F.R.S., to the Royal Society, in 1756. ("New Principles of Gunnery," London, 1761.)

A sheet of foolscap is rolled into a cylinder, and the overlapping edges gummed. Two paper clips are bent into the shapes (1) and (2) as shown in the accompanying figure, and the upper clip is rolled between the thumb and forefinger, using both hands alternately (3).

The pendulum is swung (1) without rotation, (2) with rotation to right, and (3) with rotation to left.



The behaviour of the pendulum under the three different conditions is most perplexing to the uninitiated. It is, of course, completely explained by the circulation theory.

The effect was rediscovered by Professor Magnus, of Berlin, in 1852, and is generally called after him; but, in justice to its original discoverer, might fairly be called the Robins' effect.

I am, &c.,

London, December 9, 1924. A. R. LOW.

"THE WHITWORTH SCHOLARSHIPS."

TO THE EDITOR OF ENGINEERING.

SIR,—The probable reason why most of the Whitworth scholarships go to dockyard or shipyard apprentices is that there are certain "plums" open to these boys as a reward for excellence in schoolwork. There are no such definite incentives in ordinary commercial engineering establishments, and because of this the cleverest boys from the elementary schools (the usual recruiting ground for the artisan class) are not encouraged by their teachers or parents to enter the engineering trade. So far as one's experience goes the very few who win these awards from ordinary establishments make what haste they can to get a teaching or official appointment, and an acquaintance with the managements of many shops in one of the most important engineering areas in Great Britain reveals among them but two Whitworth scholars, and they elderly men. Obviously this is not what Whitworth intended, and one supposes that employers who regard the distribution of the scholarships as a valuable indicator of the relative quality of the apprentices in the various establishments will, in time, insist on some standard of theoretical knowledge in candidates for promotion.

Yours, &c.,

Stockport, December 15. FITTER.

TO THE EDITOR OF ENGINEERING.

SIR,—Mr. Ottewell's letter on this subject is attracting very interesting expressions of opinion from various quarters. Perhaps the most correct view so far has been given by Mr. Thomas, although he leaves us to formulate the obvious deduction: that a man who did not sit for an examination may have, and often has, a greater technical value than one who has devoted his time to the required study and has been successful in passing. Every works manager who has engaged an assistant on the faith of academic qualifications alone has found this to his cost.

If I remember rightly, the late Sir Frederick Bramwell in one of the addresses he delivered some twenty years ago disclosed the fact that he never sat for an advanced examination, and it may be correctly surmised that, had he sat, he would have failed; among other things he boasted that he had never learned the calculus. The late Dr. S. P. Thompson, when consulted by a student who wished to enter the engineering profession as to the advisability of taking a degree, told him that a degree would be of no use whatever!

The writer may have been specially unfortunate in the men with whom he has been brought in contact in the course of technical business intercourse, but his experience is such that he heartily endorses this opinion, and considers an Honours B.Sc. degree or a Whitworth Scholarship, *if they are one's only qualifications*, of comparatively little value. The latter is the higher qualification only because it carries with it a guarantee of a sound practical training, which the former entirely

lacks. An academic distinction, obviously, cannot spoil a good man, but it is only a final coat of varnish on an otherwise well-built structure—"for the look of the thing." The writer would be seriously handicapped if he exchanged his practical experience for the highest academic distinction in the world.

To reform our examination system is hopeless. Let us, therefore, learn to appreciate their results at their true value and judge our men according to a different standard. Opinion will vary widely as to what this standard should be. On one extreme, we find Professor H. H. Turner, who asserts that mathematics (the only "exact" science a knowledge of which can only be tested by examination) fits one for any emergencies, including that of dealing with an Arab camel-driver who is shamming sick. (Presidential Address to the Mathematical Association, 1910.) The other extreme may be found in the credit attached to the Fellowship of the Royal Society, admittance to which is solely based on achievement, academic distinctions having no weight at all.

The fault with nearly all University graduates is that they have not a single original idea in their heads. Clearly a man cannot both study to pass examinations and labour to produce results useful to his fellow men. The two kinds of work are entirely antagonistic, but the man who has produced some useful piece of research or co-ordinated the work of others in a manner adapted to the advancement of knowledge, and has succeeded in presenting his work to the world, gives infinitely more serious guarantees as to practical ability, endeavour, perseverance and "grit," than if he had won a whole array of diplomas. Such a man could hardly have gone through a practical training without acquiring the ability of adapting himself to new calls that may be made upon him.

When the writer wants to judge of the technical value of a man, he does not trouble as to his degrees, &c., he inquires what the man has produced. A good paper read at a Students' Engineering Society, a mere article of value in a technical publication of repute, carries much more weight, and, when all is considered, justly so.

I beg to sign myself—although well aware of the inferences that may (and will) be drawn therefrom—

Not a B.Sc.

London, December 15, 1924.

DUTCH EAST INDIES TRADE.

The state of trade in the Far East is of the greatest importance to England on account of our own possessions there and also because of our dependence on foreign trade for existence. Of the various commercial customers with which we have to deal, the Dutch possessions, by reason of their natural wealth, prosperous history, and insular position, occupy a prominent position in our markets—a position which, unfortunately, does not appear to have been advancing of late years. Throughout the East, as well as the West, the period following 1920–21 has been one of acute business depression when the keenest price-cutting has taken place between different manufacturers in an effort to secure orders. A good idea of conditions in the East may be obtained from the Report on the Economic Situation of the Netherland East Indies for the year preceding July, 1924, compiled by Mr. H. A. N. Bluett and published by the Department of Overseas Trade, 35, Old Queen-street, London, S.W. This report indicates that a definite improvement in export trade was maintained throughout the period under review. The production of crude oil for 1922 increased to 2,382,398 metric tons, compared with 2,351,508 for the preceding year. Among metals, tin was sold at prices yielding high profits, the quantity exported for the year 1922–23 amounting to approximately 30,000 metric tons. During 1923 gold and silver to the value of nearly 460,000*l.* were also exported, largely to the United States, while the manganese ore shipped totalled 3,947 metric tons. Coal produced in 1922 amounted to 1,031,936 metric tons, while the figures available for the succeeding year indicate a substantial increase.

Corresponding to this recent improvement in the export trade of the Indies, the imports have substantially increased. In particular, a better demand for machinery now exists, stocks held over from the over-importation of 1920–21 having been now assimilated. Electrical and hydraulic machinery are urgently required for power stations and town lighting. Sugar factories, five of which are being built during 1924–25, are also in need of plant. An increasing demand is apparent for mechanical equipment for tea and coffee estates, the supply of which is entirely in British hands. As a direct result of the improved financial position of the States, the Government are expected to place orders for locomotives and rolling stock in the immediate future. Road rollers and small oil engines are, at present, much sought after. In metal manufactures such as plates, bars and galvanised sheets, Great Britain secured orders for barely 31 metric tons out of a total of 508 metric tons imported during 1923, Germany supplying 151 tons. Again, from January to May, 1924, out of total imports of 588 metric tons of metal goods, Germany supplied 360, while Britain provided only 13 metric tons. Of sheets, bars and rods, &c., imports from Belgium have shown a steady increase during the past three years, the figures for the first five months of each year in 1922, 1923, and 1924 being 1,373, 2,273, and 7,658 metric tons, respectively. Further, Germany is rapidly displacing this country as the principal supplier of copper manufactures, comparative figures of imports for the current year being 153 and 81 metric tons, respectively, up to the end of May. The United States is superseding this country as the supplier of zinc sheets, a state of affairs of very recent occurrence.

The greater earning capacity of agricultural estates has resulted in the creation of a better demand for motor-cars, imports to Java and Madura in 1923 totalling 2,676, against 1,502 in the year 1922, while for the current year imports to the end of May reach 1,019 cars. The demand is for American, Canadian, and Italian cars principally. The position of Great Britain in this market appears to be almost hopeless, only 12 cars having been imported in 1923 and eight in the first half of this year.

Despite the failure of the anticipated recovery in ocean-going shipping to materialise in 1923, there was a pronounced improvement in local shipping in the Archipelago, an increasing supply of cargo being much in evidence during the last months of 1923. Freights from the Dutch East Indies to Europe were increased for different products in 1923 and again during this year, those for the reverse journey being slightly reduced. Railway electrification is now being proceeded with on certain routes, and it is expected that the service on the new electric railway, Meester Cornelis–Tandjong Priok, will be inaugurated about the present time. The Oebroeg hydro-electric installation which derives power from Tjitjatih River, where a maximum of 70,000 h.p. will be generated, is now nearing completion. The South Sumatra Railway branch line from Moeara Enim has been extended to Lahat, and this section was opened for traffic in May, 1924. For the year July, 1923, to July, 1924, ten locomotives of the Mallet type were ordered by the Colonial Office at the Hague, six of which have been delivered. Road improvement is a feature in Java and the outer islands at the present time, giving rise to a considerable demand for cement, &c.

THE LATE MR. STEPHEN HARDING TERRY.

The death of Mr. Stephen Harding Terry occurred on December 15 at Upcott, Seaton, Devon, after a brief illness. The deceased gentleman, who was 71 years of age, received his scientific education at King's College, London, and from 1872 until 1875 served a pupilage with Messrs. Aveling and Porter, of Rochester. Later he was engaged with Messrs. Clayton and Shuttleworth, of Lincoln, with which firm he gained experience in drawing office and field work. At the beginning of the year 1880, Mr. Terry commenced work with the Local Government Board as an Assistant Engineering Inspector, and in 1884 was promoted to the rank of Inspector, a position which he held for five years. During these years he got out type drawings for standard sewerage and water supply arrangements, and reported on every kind of work carried out by the local authorities under the Public Health Act. At the conclusion of this period he became a managing partner in the firm of Messrs. King, Masterman and Terry, having large works situated in Staffordshire and engaged in the construction of large steam and hydraulic cranes, colliery winding and pumping engines, waterworks requirements, and petroleum storage tanks. The firm provided steam cranes for the Belfast Harbour Commission and the Belgian State Railways, as well as gas and water supply plant at Audley. Further, an electric light station at Woking was equipped by them. For some 20 years Mr. Terry practised as a consulting engineer, advising on work in connection with gas, water, and heating, forced draught and ventilation of ships, petroleum storage and refuse destruction. In conjunction with Sir Fortescue Flannery, he devised and patented the universally adopted system of petroleum ship ventilation. A member of the Institution of Civil Engineers, the Institution of Mechanical Engineers and the Institution of Marine Engineers, Mr. Terry contributed many papers to different societies and numerous letters to this journal.

The Calcutta Electric Supply Corporation Limited.—For the nine months preceding September 30, 1924, the Calcutta Electric Supply Corporation Limited, sold 61,764,926 units, compared with 49,041,435 units for the corresponding part of 1923.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Iron and Steel.—The recent improvement in South Yorkshire trade has been maintained, and business generally in raw and semi-finished steel products is slowly expanding. Forward buying tends to become more prominent, but the majority of consumers find it necessary to take a record of their stock before committing themselves to actual business. Prospects in all departments of the steel trade are considered bright, while the lighter sections are in a stronger position. There is a steady flow of contracts, and following those placed by the London and North Eastern Railway Company with local makers of goods wagons comes the information that the London, Midland and Scottish Railway Company are embarking upon a reconstruction scheme to cost 14,000,000*l.* It is expected that firms in this district will benefit, but whether directly or indirectly it is not known. Colliery enterprise is responsible for the placing by the Blackwell Colliery with a local firm a contract for one of the largest batteries of modern by-product coke ovens in the country, which comprises a coal washery plant capable of washing 75 tons of coal per hour and storage and drainage bunkers of 2,000 tons capacity, as well as a by-product coke oven battery with 40 regenerative ovens. With other additions the total cost of the plant is placed at about 200,000*l.* Shipbuilding steel fails to make any headway but automobile steel makers report big increase in output. Railway departments are busily engaged, and with big railway developments pending in this and other countries there is no reason why the future should not be viewed with optimism. The Colonies are transacting a big volume of trade with implement and machinery makers, while home users are buying a little more freely. In the tool trade an improvement is noticeable. Contracts have been booked by makers of files both on home and foreign account, and the Dominions are calling for increased supplies of implements and general engineer's tools. Business in tool steel shows signs of expanding. Buying is not only confined to home purchasers but Continental users are inclined to re-enter the market.

South Yorkshire Coal Trade.—The amount of business passing fails to attain a normal level. The only really active line is in best steams, for which there is a strong call on home account, while increased tonnages are going away for shipment. Cobbles, nuts and slacks are reviving, but are far from satisfactory. House coal continues to disappoint, and though a slight improvement is reported, merchants have difficulty in disposing of stocks. Foundry and furnace coke maintain their recent improvement. Gas coke is firm. Quotations: Best branch hand-picked, 32*s.* to 35*s.*; Barnsley best Silkstone, 26*s.* to 28*s.*; Derbyshire best brights, 27*s.* to 32*s.*; Derbyshire best house, 24*s.* to 26*s.*; Derbyshire best large nuts, 22*s.* 6*s.* to 25*s.*; Derbyshire best small nuts, 14*s.* to 16*s.*; Yorkshire hards, 20*s.* to 22*s.* 6*d.*; Derbyshire hards, 19*s.* 6*d.* to 22*s.*; rough slacks, 9*s.* 6*d.* to 12*s.*; nutty slacks, 8*s.* 6*d.* to 10*s.* 6*d.*; smalls, 4*s.* to 6*s.* 6*d.*

The Late Mr. M. L. Hall.—We regret to record the death of Mr. Martin Luther Hall, which occurred at his residence, Spring Bank, Smallshaw, Ashton-under-Lyne, on the 10th inst. The deceased gentleman, who was 67 years of age, was the Managing Director of Messrs. Joshua Heap and Co., Limited, of Oldham-road Engineers' Tool Works, Ashton-under-Lyne.

Improvements at Holyhead.—It is proposed to increase the lairage at Holyhead, to enable considerably larger shipments of cattle to be made from the Irish ports to Holyhead than at present. In anticipation of the time when the L.M.S. mail steamers will be able to arrive at the inner harbour, instead of at the Admiralty Pier, as at present, the station at Holyhead is also to be greatly improved.

Compounds of Helium.—It has hitherto proved impossible to induce helium, argon, or any other of the "noble gases" to enter into chemical combination. In a recent issue of *Nature* however, Mr. J. J. Manley, of the Daubeny Laboratory, Oxford, states that under certain conditions, and in the presence of an electric glow discharge, mercury and helium combine to form a mercury helide, which is a stable compound and not readily decomposed save at or above a bright red heat.

Engineering Lock-out in Belgium.—In order to put an end to the series of small strikes which have been taking place recently in Belgium, the Constructional Engineering Federation has decided to proclaim a general lock-out in Brabant on December 14 in the event of their continuance. Should this lock-out fail to produce the desired effect, it will be extended to include the whole country. The metallurgical industry as a whole will not be affected, however, the lock-out being confined to the mechanical engineering industry.

Production of Iron and Steel in November.—The production of pig-iron in November amounted to 583,500 tons, compared with 586,400 tons in October, a slightly higher daily rate. The number of furnaces in blast increased by two during the month of November to 173. Included in the production of pig iron were 197,500 tons of hematite, 178,800 tons of basic, 150,300 tons of foundry and 31,700 tons of forge metal. The output of steel ingots and castings amounted to 672,800 tons, compared with 678 tons in October and 645,000 tons in September.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Extreme quietness characterises business in Cleveland pig-iron, but inactivity is usual at this dull period of the year, and hope is entertained that a fair amount of brisk trade will be experienced as soon as the Christmas holidays are over. The statistical state of the Cleveland pig-iron branch is very healthy. Producers have practically no stocks, but some accumulations at makers' yards must now be looked for with the approach of the time when consumers close down their works for the holidays. Makers are not pressing sales, and merchants are not at all keen to make price concessions to secure orders. No. 1 Cleveland is 86*s.* 6*d.*; No. 3 g.m.b., 81*s.* 6*d.*; No. 4 foundry, 80*s.* 6*d.*; and No. 4 forge, 80*s.*

Hematite.—Stocks of hematite are still considerable, and likely to increase a little in the near future, but with the turn of the year requirements promise to be such as will more than absorb the anticipated enlarged output. For the time being quotations are easy. Nos. 1, 2 and 3 East Coast brands are round about 88*s.*, and No. 1 is put at 6*d.* above mixed numbers.

Foreign Ore.—Imported ore is slow of sale, and definite quotations are not easily fixed. Unloadings against contracts, however, are on a fairly good scale. Sellers base quotations on best rubio at 22*s.* 6*d.* c.i.f. Tees.

Blast-furnace Coke.—There is improved demand for blast-furnace coke, and though supplies continue ample, values are stiffening. Durham good average qualities are fully 25*s.* delivered to consumers in this district.

Manufactured Iron and Steel.—The outlook in the manufactured iron and steel industries is regarded as better. Fairly good business is looked for in railway material, and constructional steel and galvanised sheet makers are heavily sold. Common iron bars are 12*l.*; iron rivets, 14*l.*; packing (parallel), 10*l.*; packing (tapered), 11*l.* 10*s.*; steel billets (soft), 8*l.* 10*s.*; steel billets (medium), 9*l.*; steel billets (hard), 9*l.* 10*s.*; steel boiler plates, 13*l.*; steel ship, bridge and tank plates, 9*l.* 15*s.*; steel angles, 9*l.* 10*s.*; steel joists, 9*l.* 10*s.*; heavy steel rails, 9*l.*; fish plates, 12*l.*; and galvanised corrugated sheets (24-in. gauge, in bundles), 17*l.* 10*s.*

THE SOCIETY OF ENGINEERS (INCORPORATED).—At the annual general meeting of the Society of Engineers, held at 17, Victoria-street, London, S.W. 1, on December 8, it was announced that the President's Gold Medal, presented for the most meritorious paper read during the year 1924, had been awarded to Mr. James Jackson for his paper on "Development of Methods for the Collection and Disposal of House (Domestic) Refuse." The Bessemer Premium was secured by Mr. H. A. Rickwood for his paper on "Recent Developments in Ferro-Concrete Cooling Towers."

NEW ROLLING-STOCK FOR THE L.M. & S. RAILWAY.—A considerable proportion of the 14,000,000*l.* which the London, Midland & Scottish Railway propose to spend on their recently announced programme of extensions and renewals will be allocated to locomotives and rolling-stock. Provision has been made for the building of some 235 new locomotives, of which 220 are to be large passenger and freight engines and 15 smaller passenger locomotives for special routes. The most costly item in the programme, however, is the construction of wagons, of which no fewer than 30,000 are to be built. A large number of these will be for the conveyance of coal and minerals, and it is to be hoped that the company will take advantage of the opportunity to adopt a modern and progressive policy with regard to size. An expenditure of nearly 5,000,000*l.* on new coaches provides for the building of 2,591 passenger coaches, mostly of the vestibule and corridor type. Forty new kitchen cars are to be constructed, each capable of furnishing 250 meals at one sitting, a capacity four times that of the ordinary dining-car kitchen. New refrigerator cars and hygienic cattle cars are also to be built.

SHIPBUILDING BY MESSRS. HARLAND AND WOLFF, LIMITED.—The tonnage returns issued by Harland and Wolff, Limited, show that during the year 1924, for the third year in succession, they have launched over 100,000 tons of shipping, with over 88,000 i.h.p. This is a notable record in a time of depression such as the shipbuilding industry has been passing through. The work at Belfast included some of the largest vessels of the year—the Statendam (28,500 tons) and the Minnetonka (22,000 tons). During the year the motor vessel Lochmonar was completed, and considerable progress made with the mail and passenger vessels for the Royal Mail Company and Union-Castle Line. It may be mentioned that these latter vessels are the largest motor vessels under construction. A number of motor vessels for the Bank Line were completed at the Govan yard during the year. In addition to the new construction at Belfast, several large repair and overhaul operations were carried out, including those of the White Star liners Olympic (46,400 tons) and Homeric (34,300 tons), the latter vessel having been arranged for oil fuel burning while in the hands of the firm. The R.M.S.P. ss. Araguaya was also extensively overhauled and improved by them at Belfast, and besides other work of an important character they have in hand the repairs of the ss. Bardic, of the White Star Line, and the reconstruction of H.M.S. Caroline. The last-named ship is being fitted out as a training vessel for use in the Naval Volunteer Reserve.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

Trade of Welsh Docks.—In the eleven months ended November, the import and export trade of the South Wales docks, according to returns of the Great Western Railway Company, amounted to 37,188,969 tons, or 3,868,679 tons less than in the corresponding period of last year. The reduction was entirely due to a diminished export trade, brought about by the depression in the coal trade. Exports alone amounted to 31,661,860 tons, a reduction of 4,075,736 tons, but imports at 5,527,109 tons were increased by 207,057 tons, the returns being as follow :—

	Jan. 1 to Nov. 30. 1923. Tons.	1924. Tons.
Exports.		
Coal and coke	32,972,405	28,736,989
Patent fuel	823,169	893,446
Iron and steel rails and iron-work	423,071	293,312
Tinplates	542,843	640,078
Cement	59,060	60,192
Grain and flour	121,228	125,858
Oil	654,541	771,081
General merchandise	140,541	140,806
Ballast	738	98
Totals	35,737,596	31,661,860
Imports.		
Iron ore	1,109,757	1,053,687
Copper and other ores ...	60,018	120,512
Iron and steel	466,350	797,299
Timber and deals	209,000	273,334
Pitwood and mining timber ...	1,376,810	1,177,902
Grain and flour	484,104	524,253
Oil	915,089	935,920
General merchandise	609,467	538,041
Building sand	87,154	101,739
Ballast	2,303	4,422
Totals	5,320,052	5,527,109

Exports of coal and coke were reduced by 4,235,416 tons, and those of iron and steel rails and ironwork by 129,759 tons, but shipments of patent fuel were increased by 70,277 tons, of tinplates by 97,235 tons, and of oil by 117,540 tons. Imports generally were greater, that of copper and other ores being increased by 60,494 tons, iron and steel by 330,949 tons, and grain and flour by 20,831 tons. The total trade of each of the ports was lower, that of Cardiff falling from 10,452,420 tons to 9,618,582 tons, Penarth from 3,233,380 tons to 2,846,691 tons, Barry from 10,058,418 tons to 8,891,604 tons, Newport from 7,384,315 tons to 6,392,333 tons, Swansea from 6,927,739 tons to 6,762,005 tons, and Port Talbot from 3,001,376 tons to 2,677,754 tons.

The Coal Trade.—As most collieries are booked up till the end of the year and working is more regular than for some weeks past, prices generally are steadily upheld for all classes of large coals, though smalls are more easily stemmed, which is due to an increasing output in consequence of an increased production of large coal. A month ago best small coals, without large, were firm at 17*s.*, but if taken in conjunction with large could be secured at 1*s.* 6*d.* to 2*s.* less. At present, however, best smalls are steady at 16*s.* to 16*s.* 6*d.*, whether taken in conjunction with large or not. Best Admiralty large coal is steady at 27*s.* 6*d.*, with Monmouthshires from 24*s.* to 25*s.*

Iron and Steel.—Exports of iron and steel goods last week totalled 22,920 tons, the largest quantity for some weeks past, compared with 13,780 tons in the previous week. Shipments of tinplates and terneplates totalled 10,884 tons, against 5,127 tons; black plates and sheets 7,038 tons, against 3,377 tons; galvanised sheets 3,539 tons, against 2,132 tons; and other iron and steel goods 1,460 tons, against 3,145 tons.

SULPHURIC ACID PLANT.—At a meeting on Wednesday, December 3, of the Liverpool Engineering Society, when the President, Mr. Ralph E. Gibson, M.Inst.C.E., occupied the chair, Mr. C. S. Imison, M.A., delivered a lecture on "Sulphuric Acid Plant." In this he described the various stages and alternative methods of working in the manufacture of this valuable chemical and referred to the construction of the component items in the complete plant.

TRIALS OF THE SS. "SKEGNESS."—On Saturday, December 13, a series of trials was successfully run in Belfast Lough, with the ss. Skegness, built by Messrs. Workman, Clark and Co., Limited, Belfast, for Sir William Reardon Smith and Sons, Limited, Cardiff. She is a shelter-deck type vessel with top-gallant forecastle and has a length of 415 ft., a beam of 54 ft., and a gross tonnage of 4,570 tons. The ship was built to the requirements of the British Corporation for their highest-class B.S.* "with freeboard." In this vessel, special arrangements have been made for the carriage of grain and general cargoes, five large holds being equipped with very complete loading and discharging arrangements. Water ballast, or oil fuel, can be carried in the double bottom, and when required, a cargo hold has been constructed to serve as a deep tank for ballast or oil fuel. The machinery, which was also constructed by Messrs. Workman, Clark and Co., Limited, consists of a vertical surface condensing triple-expansion engine taking steam from three multitubular cylindrical boilers, arranged to burn either coal or oil. On the conclusion of the trials, the vessel left for the Bristol Channel to load cargo.

NOTICES OF MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS.—To-night at 6 p.m., at Storey's-gate, S.W.1. General Meeting. Second Report of the Wire Ropes Research Committee.

THE JUNIOR INSTITUTION OF ENGINEERS.—To-night at 7.30 p.m., at 39, Victoria-street, S.W.1. Lecture: "Aircraft in Japan" (preceded by "A Few Experiences of the King's Cup Race, 1924"), by Colonel the Master of Semphill.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—No feature of any importance has been noticeable in the steel trade of Scotland during the past week, and with no expansion in general trade, dullness prevails all round. The demand for material is not expected to amount to any heavy tonnage this year now, and consumers are only specifying for their immediate needs, and they are generally not much. The shipbuilding industry has been doing fairly well of late, but the unfortunate thing from the steelmaker's point of view is that a great deal of foreign steel has been used here. The Continental prices have been very cheap, but a hardening up has taken place and that is all in favour of the home makers. At the present moment, however, the outlook is not very encouraging, and there is a fear that the year-end stoppage of the works will be of a prolonged nature. This will probably not be the case with the black sheet makers, who are mostly well booked into the spring months for the lighter gauges and are now busily employed. Galvanised sheets have been the subject of good inquiry, and as stocks abroad are on the small side, it is anticipated that some good orders will be forthcoming for delivery in the early months of the year. Prices are keeping steady and the following may be taken as the current quotations for the home market:—Boiler plates, 13*l.* per ton; ship plates, 9*l.* 15*s.* per ton; sections, 9*l.* 10*s.* per ton; and sheets, $\frac{7}{8}$ to $\frac{1}{4}$ in., 12*l.* per ton, all delivered Glasgow stations.

Malleable Iron Trade.—In the West of Scotland malleable iron trade no improvement of any kind falls to be noted. Dealings are very few in number and small in tonnage, and all that consumers seem to be ordering is just sufficient to tide them over in the meantime. The outlook continues to be most uncertain, but perhaps a turn for the better may take place with the beginning of the new year and, indeed, all are looking forward with much hope. In the re-rolled steel branch things are still quiet, and any business passing is eagerly sought after but quotations require to be very keen. The price of "Crown" bars is unchanged at 12*l.* per ton delivered Glasgow stations.

Scottish Pig-Iron Trade.—In the Scottish pig-iron trade there has been little change during the past week. Business has been on the small side, but inquiries are fairly good and there are hopes of a broadening out in the near future. Deliveries to home consumers are not very heavy at present, as few are desirous of accumulating stocks towards the end of the year and only immediate requirements are being ordered. Prices show no change and are as follow:—Hematite, 4*l.* 15*s.* per ton, delivered at the steel works; foundry iron, No. 1, 4*l.* 15*s.* per ton, and No. 3, 4*l.* 10*s.* per ton, both on trucks at makers' yards.

Scottish Pig-Iron Shipments.—The shipments of Scottish pig-iron from Glasgow Harbour for the week ended last Saturday, December 13, amounted to 2,189 tons. Of the total, 2,022 tons went abroad and 167 tons coastwise. For the corresponding week of last year the figures were 1,391 tons to foreign destinations and 105 tons coastwise, making a total shipment of 1,496 tons.

The Holidays.—Arrangements for the duration of the holidays at the end of the year are not yet finally completed, but it is expected that, in the majority of the shipyards on the Clyde, they will be from Wednesday December 31, to Thursday, January 8. In the local steel and iron works it is anticipated that a longer spell will be general, and it is very possible that ten days will be the minimum with the majority of the works completely closed for a full fortnight. Everything will depend on how specifications come in within the next ten days or so.

THE NORTH-WEST MIDLANDS ELECTRICITY DISTRICT.—The Electricity Commissioners provisionally determined in September, 1920, that parts of the Counties of Chester, Derby, Shropshire and Staffordshire should be united for purposes of electricity supply, into an area under the name of the "North-West Midlands Electricity District." They failed, however, to secure agreement as to the exact area to be included, and were compelled to exclude certain portions, the remainder being recently organised under the title of the West Midlands Electricity District. It is now proposed that the greater part of the excluded area should be constituted into a district of its own under the name of the "North-West Midlands Electricity District. The proposed new district will include Stoke-on-Trent, Congleton, Market Drayton, Newcastle-under-Lyme, Stafford and other towns in the neighbourhood. Before establishing this electricity district, the Commissioners will hold an inquiry, and all interested parties are invited to submit schemes on or before February 28, 1925, to form the basis of the inquiry.

GEARED TURBINES FOR THE SS. "DROTTNINGHOLM," FORMERLY "VIRGINIAN."

CONSTRUCTED BY THE AKTIEBOLAGET DE LAVALS ANGTURBIN, ENGINEERS, STOCKHOLM.

(*For Description, see Page* 841.)

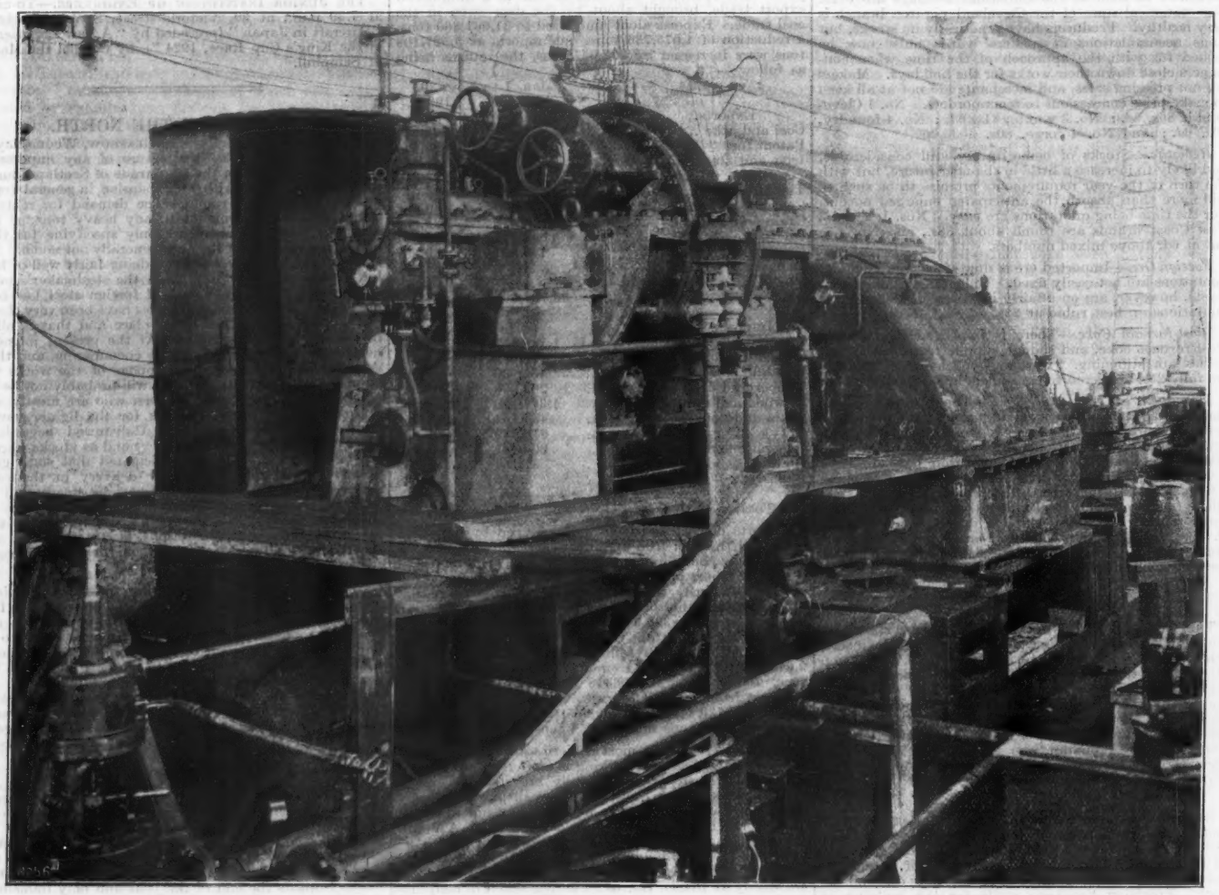


Fig. 1. View of Turbine as erected in the Builders' Works.

Cosmic Energy. — In a lecture on radioactivity recently delivered at Paris by M. Jean Becquerel, the speaker stated that the energy of the radioactive bodies formed only an insignificant fraction of the total energy stored in the universe. According to Einstein's theory of relativity, all energy, whatever its form, possessed mass, and inversely every mass represented a quantity of energy equal to the product of this mass by the square of the velocity of light. It followed, therefore, that each gramme represented in the latent state an energy which, if wholly usable, would suffice to raise a weight of 30 millions tons to the top of the Eiffel Tower. The energy liberated by a gramme of radium in 1,750 years was very large, but was less than one-thousandth part of the total energy stored in a gramme of any matter whatever.

Impregnation of Timber.—In order to facilitate the impregnation of wood with preserving chemicals, holes are pricked, or drilled, into the timber to a depth of an inch or so. Machines for this purpose were constructed about twenty years ago by F. Becker, of Vienna, and various processes have since been developed, especially in Austria and America. When the impregnation is to be limited to the lower end of a pole to be fixed in the ground, it can be effected by portable machines such as the Hatenberger and Badermils machines used by the Hungarian telegraph department. In some types needles are utilised, in others, drills or knives. In the Kobra impregnating process of a Kissingen firm, the needle is elliptical in section and hollow, and the hole made is filled with the required chemical as the needle is withdrawn; the impregnation thus takes place somewhat as the poisoning through the hollow tooth of a snake. The perforations weaken the timber, of course; but experiments made in Canada and Hungary agree that the strength will by suitable machinery not be reduced by more than a fraction of one per cent. The advantage of the treatment is a very material gain in time and a much more efficient impregnation, because the preservative is really introduced into the resinous fibre, which would resist soaking even in *vacuo*.

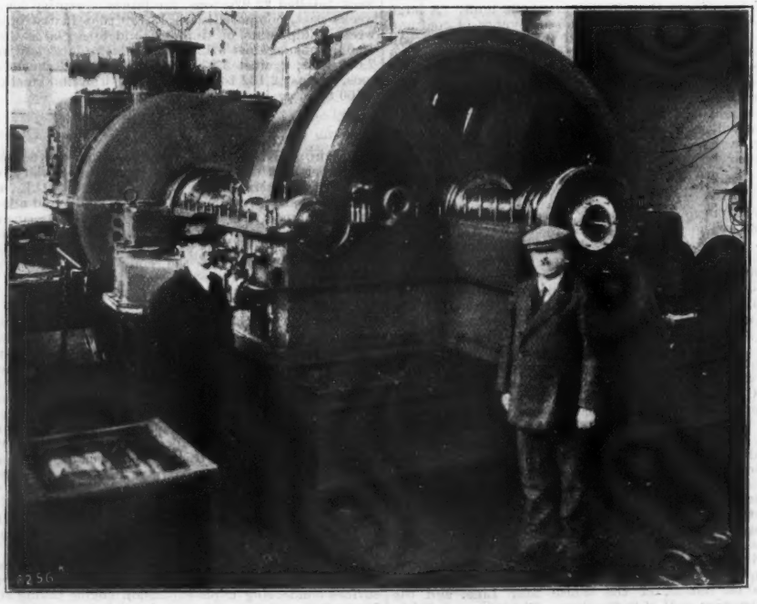


Fig. 2. Reduction Gearing.

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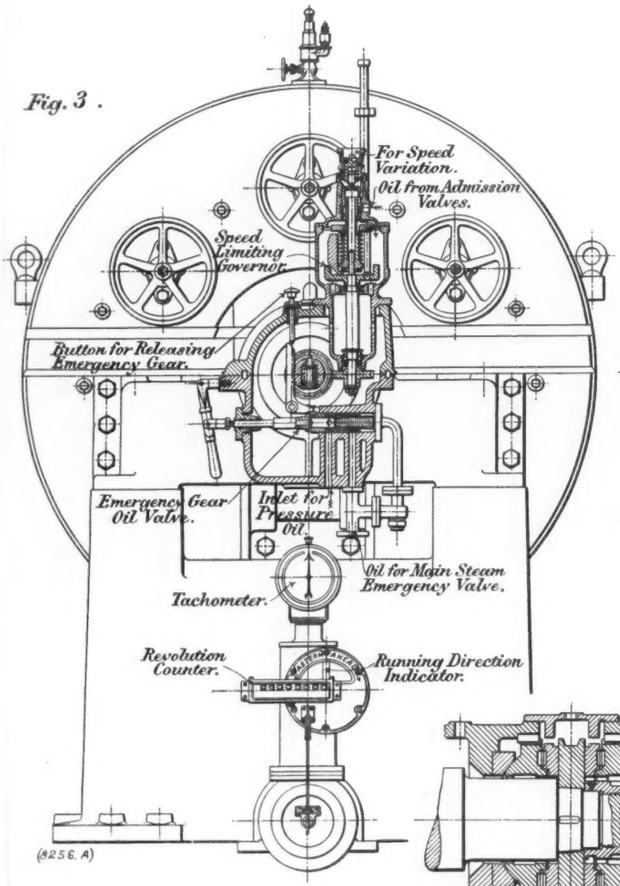
Fig. 3.



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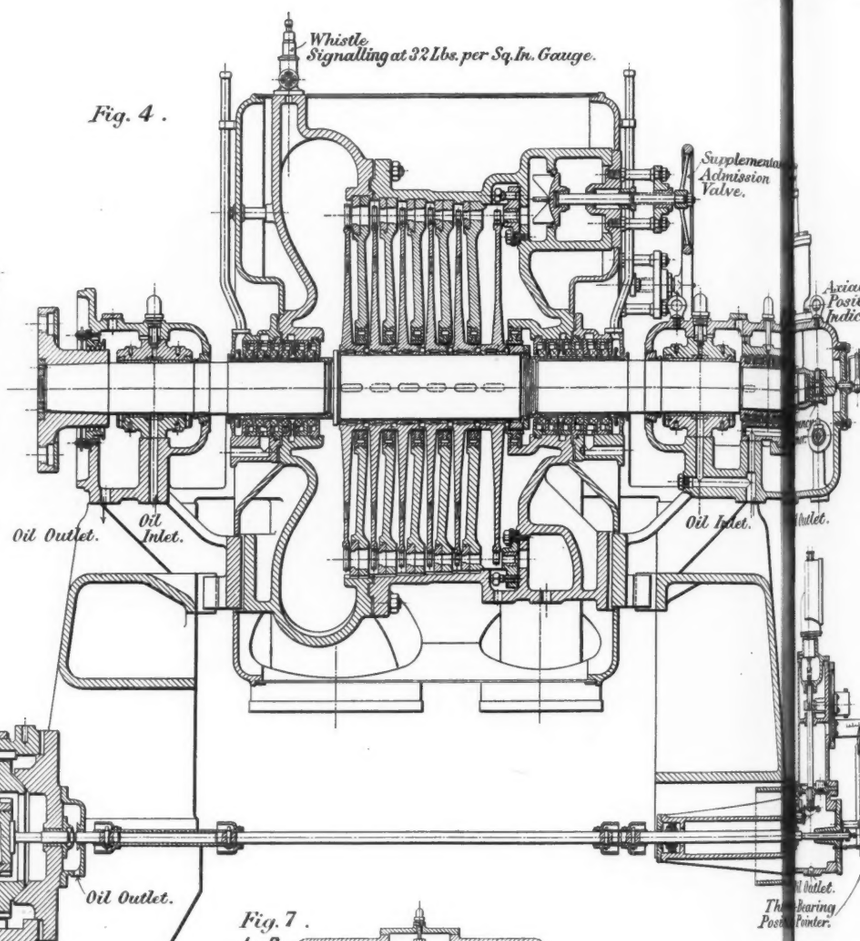

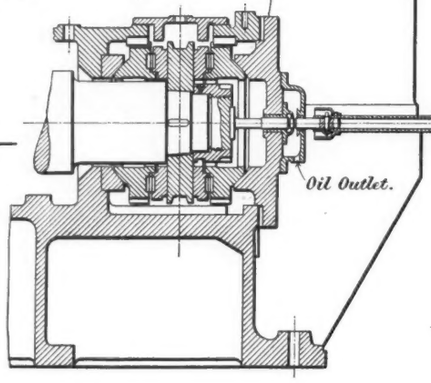

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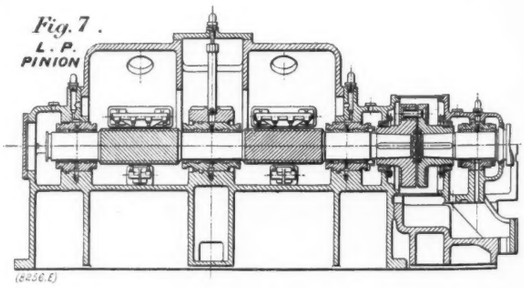

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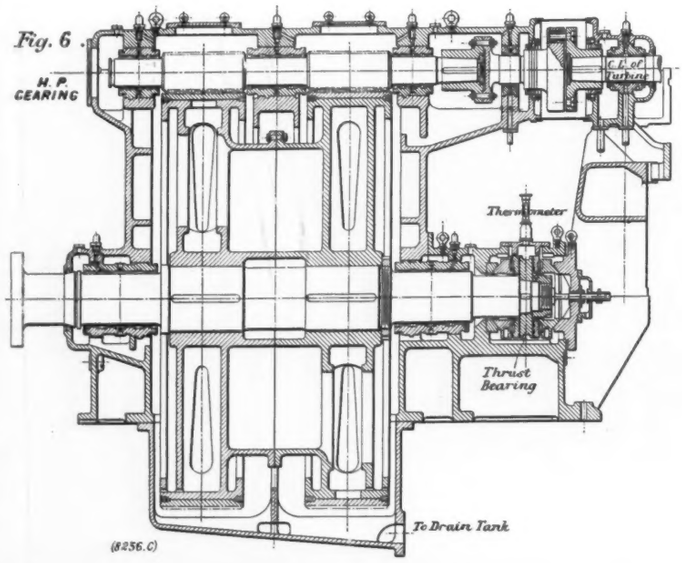

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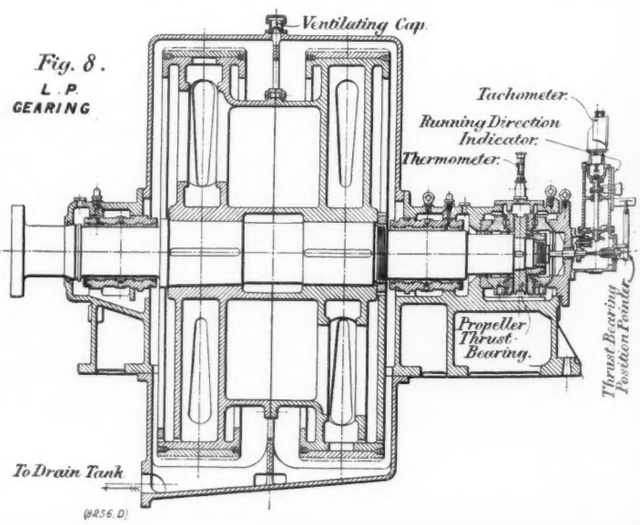

"DRONNINGHOLM," FORMERLY "VIRGINIAN."

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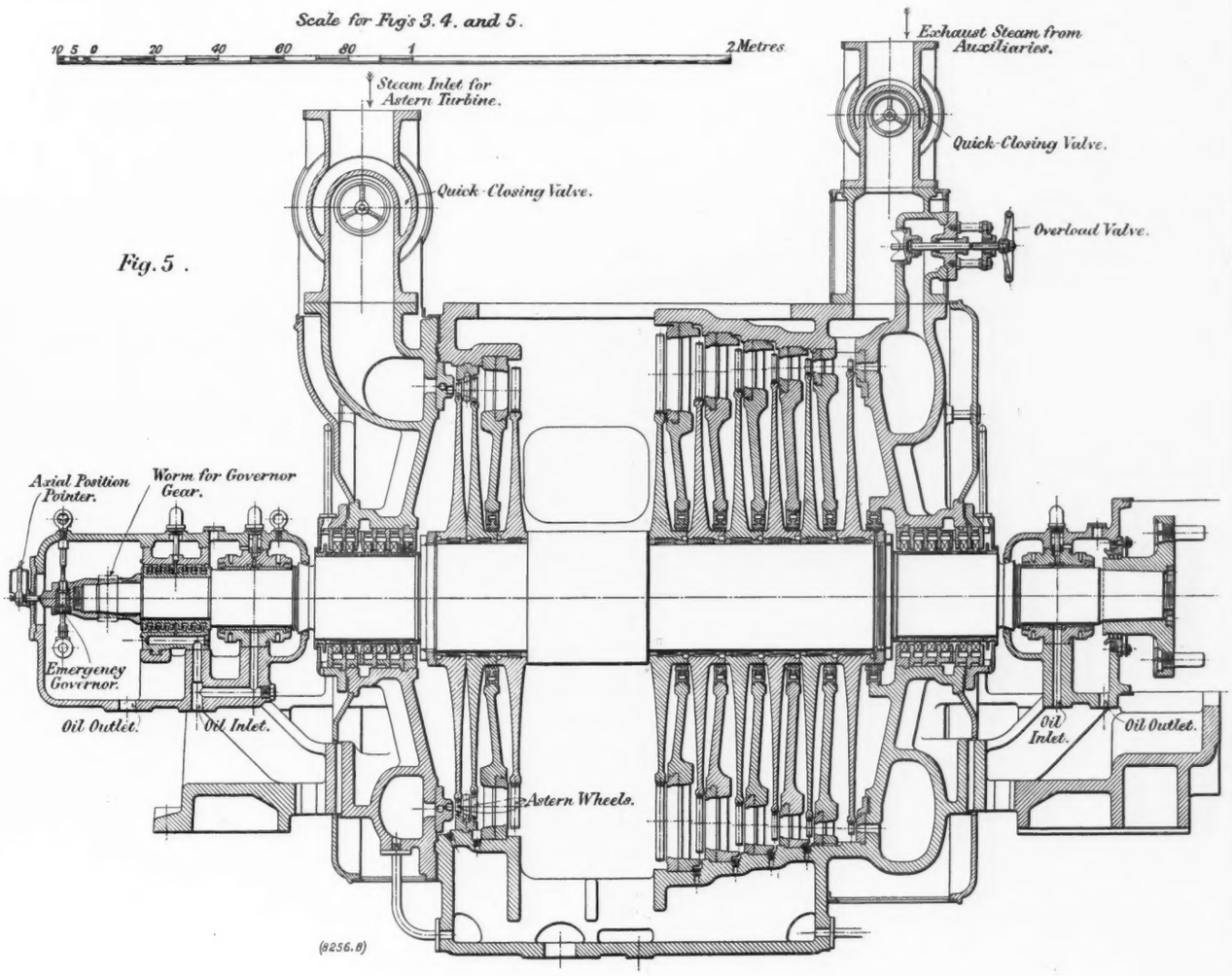
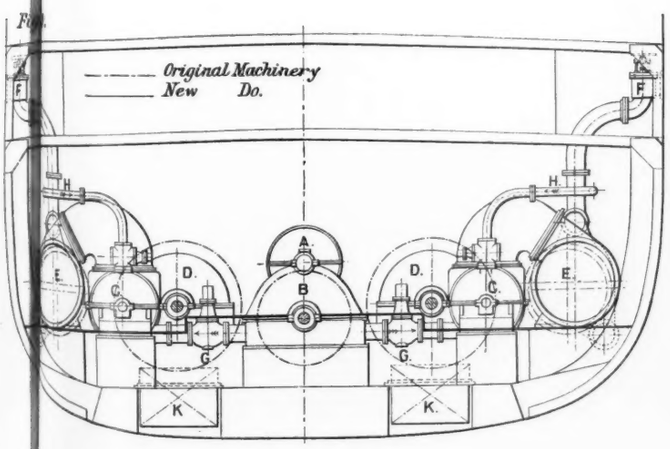
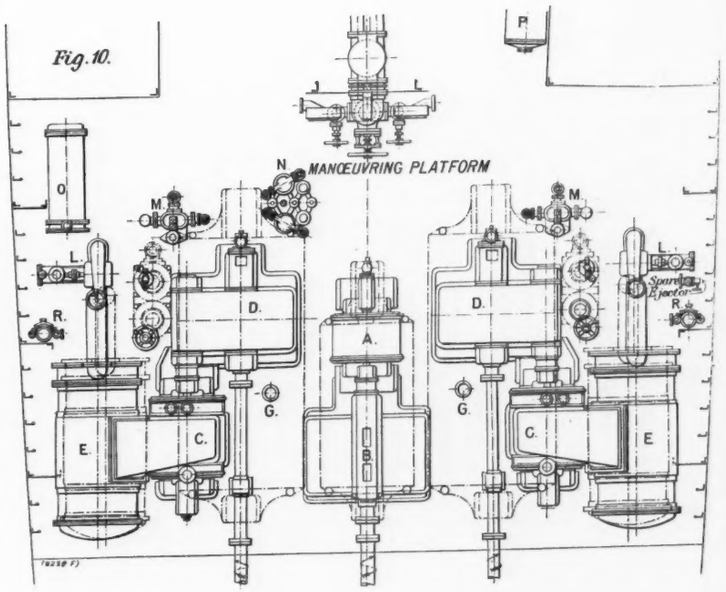
Fig. 5.







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C. L.P. Turbine.
D. L.P. Gearing.
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M. Oil Pumps.
N. Oil Cooler.
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ENGINEERING.

FRIDAY, DECEMBER 19, 1924.

STANDARDS OF THERMAL EFFICIENCY.

IN his May lecture to the Institute of Metals last spring, Dr. F. W. Aston observed that it was more important that a theory should be simple than that it should be exact. Similar considerations are probably sufficient to justify the popularity of the $\theta\ \phi$ diagram as a means of estimating the heat available for work in a pound of steam. It has long been known, however, that an isentropic expansion of wet steam is impossible, and that the heat really available below the saturation line is less than the temperature-entropy diagram or the usual Mollier chart would suggest. The total magnitude of the error no doubt is as yet somewhat uncertain, it may be large or it may be small, but, as Mr. George Sampson said about the under-petticoat, "we know it's there." Repeated experiments have, in fact, conclusively shown that a nozzle fed with "dry but saturated" steam has a greater discharge than is theoretically possible when calculated in the usual way, and the anomaly has been traced to a delay in condensation and consequent supersaturation of the steam—a phenomenon which, it is interesting to note, was indicated as possible by Clerk Maxwell in his little text-book on "Heat," published in 1880. Although such an expansion is thermally unstable, it may, nevertheless, be isentropic, but this isentropic line will not be as long as that indicated on the usual Mollier chart for wet steam. Moreover, when a certain limit of expansion is reached, moisture separates out, with an accompanying rise of temperature, increase of entropy, and loss of available heat. So far we are on certain ground, and it is possible to calculate the minimum possible loss due to the sudden and copious condensation of steam at the Wilson line. This particular loss is smaller, the higher the pressure at which the saturation line is crossed, and is thus least in adiabatic expansions. It is accordingly not large in any of the cases considered in Capt. Sankey's clearly written paper on "Standards of Comparison in Connection with the Thermal Efficiency of Steam Engines," which was reprinted on page 818 of our last issue. Thus, with steam supplied at 120 lb. per sq. in. and at a superheat of 100 deg. F. the saturation line is crossed at a pressure of about 52 lb. per sq. in., and the Wilson line at a pressure of about 32 lb. per sq. in. If at this line thermal equilibrium is restored, and the expansion subsequently continued isentropically to the exhaust pressure of 0·5 lb. per sq. in., the heat available below the saturation line will be only 1·8 B.Th.U. less than if the expansion had been isentropic throughout. As a matter of fact, however, there are very strong grounds for concluding that the losses due to supersaturation do not end at the Wilson line. In Wilson's original experiments, made as far back as 1897, he found that when the expansion was continued beyond this limit the moisture came down on additional fresh nuclei instead of depositing itself on the droplets already formed, although these numbered something like 10^{22} per lb., and thus presented an enormous surface theoretically available for condensation. There is no reason for supposing that steam acts differently in an actual steam turbine, and the total loss of available heat in an ideal turbine using steam saturated at 200 lb. absolute and expanding adiabatically to a 28 in. vacuum, may quite possibly be of the order of 8 per cent.

This figure leads to estimates of turbine efficiencies which have been repeatedly verified by comparison with actual test figures; but the large loss of available heat, above mentioned is still lacking confirmation by direct experiment. Until results thus derived have been published, it is perhaps just as well to accept at least provisionally existing methods of estimating available heat.

It is, however, very desirable that there shall be a general agreement as to details, and it seems improbable that builders and contractors will agree to Capt. Sankey's suggestion that where progressive feed heating is adopted, the number of stages in the process shall be considered as infinite, whereas, there is little probability, for commercial and mechanical reasons, that turbines will be "bled" for feed-heating purposes, at more than a very limited number of points. Contractors are pretty certain, therefore, to base their own estimates of available heat on the feed-heating cycle they actually use, and unless the committee concedes this point it seems possible that their recommendations may fail to secure unanimous support. What the committee have done is to recommend two different standard cycles of comparison, one for application to turbines with no feed-heating arrangements, and the other for turbines with such arrangements. In the latter case, as we have said, the ideal condition of an infinite number of heating stages is assumed. The contractor who does not adopt feed heating, therefore, has his product compared with a perfect machine working on the same cycle as that at which he is aiming, whereas the one who seeks to obtain any part of the higher efficiency which feed-heating permits, has to compare his machine with one working on a practically unattainable cycle. The better turbine therefore will show a lower efficiency ratio than the other, which is certainly not as it should be. The committee could obviate this difficulty by requiring that all turbines, whether using feed heating or not, should be compared with the full feed-heating cycle, so that a manufacturer would disregard progressive feed-heating at his own risk. This would be more logical than the proposals of the committee, although it is still open to the objection that manufacturers might decline to do it.

Mr. Kearton in his contribution to the discussion on Capt. Sankey's paper last Thursday indicated one possible method of securing the ideal standard of progressive feed heating. It involved the compression by mechanical work of the steam withdrawn for feed heating. Such a procedure, as he observed, is, of course, not free from objection on the practical and mechanical side.

In principal the method would correspond to the following cycle: assuming the steam to be initially saturated, it is expanded in a non-conducting cylinder down to the condenser pressure. The exhaust valve is then opened and part of the steam condensed. Before the end of the return stroke, however, the exhaust valve is closed, and the condensed steam returned

to the cylinder. The stroke is then completed, by adiabatically compressing the mixture of steam and water. If the point of closing the exhaust valve is correctly chosen, the result will be that at the end of the stroke the steam will all be condensed and the clearance will be completely filled with water at the initial temperature. It can then be re-evaporated and the cycle begun anew. Such a cycle would have the same efficiency as the Carnot cycle, which is, of course, not the only theoretically perfect cycle. Though no cycle can have a higher efficiency than the Carnot cycle there are others equally good; of which the earliest devised seems to have been that adopted by Stirling as the basis of his regenerative hot air engine.

Assuming that an agreement can be reached as to how available heats are to be calculated, the additional question arises as to what use is to be made of the results. The common practice is to estimate turbine efficiencies as the ratio of the heat value of the work actually done to the available heat. The efficiency ratio thus determined is, however, far from satisfactory as an indication of the relative merits of turbines operating under different conditions. A water turbine which shows on test an efficiency of 82 per cent. is undoubtedly superior to another which can only attain 80 per cent. efficiency, but we cannot say that a steam turbine giving on test an efficiency ratio of 82 per cent. is necessarily of better design than one, which, tested under different conditions (though perhaps with the same thermodynamic head as ordinarily estimated), shows an efficiency ratio of only 80 per cent. It is this fact which makes it important that some satisfactory method of determining the heat available below the saturation line, should be devised. This would make efficiency ratios somewhat more comparable *inter se*, but would not eliminate all the objections to the use of these ratios as a criterion for appraising the merits of different designs of turbine.

This will readily appear, if we consider the ideal case of two turbines operated with a perfect gas and expanding down to zero pressure. It can be shown that in these circumstances both will have an efficiency ratio of unity, whatever the stage efficiency may be. The relative friction losses per stage might be twice as great in the one case as the other, yet, as stated, both would have unit efficiency ratio, though the stage efficiency of the one might be, say, 60 per cent. and of the other 80 per cent.

The above considerations are sufficient to show that to take the efficiency ratio as a standard for comparing turbine performances is somewhat analogous to constructing a tape measure of elastic. If nothing better were available, such a tape might prove fairly useful in the hands of one who thoroughly understood its peculiarities, but would be well calculated to mislead the inexpert. Turbine designers, of course, are thoroughly conversant with the real significance of an efficiency ratio, and when comparing tests made under different conditions correct the recorded efficiency ratios by certain empirical coefficients.

Apart from questions of reliability the station engineer and the consultant are mainly concerned in the British Thermal Units expended per kilowatt hour. We should, however, be sorry to see a return to the early practice in the recording of steam turbine tests, in which, in general, only the figures of interest to possible customers were published, and it was exceedingly difficult to get data of any technical value or interest. It would seem, however, sufficient if steam conditions both above and below the governor valve were recorded, and the vacuum at the condenser. With these and the steam rate per "indicated" kilowatt the "expert in the art," can readily work out a true figure of merit which is, as indicated above, only very imperfectly represented by the efficiency ratio taken *per se*.

FUEL OIL FOR MARINE ENGINES.

Without wishing to question that "there are still some burning topics in connection with oil," as Mr. Sterry B. Freeman put it in a paper on "Fuel Oil for Marine Internal-Combustion and Steam Engines," read at Newcastle-upon-Tyne before the North East Coast Institution of Engineers and Shipbuilders on the 12th inst., we would submit that the fuel oil problem is too much considered as singular and with too little regard to historical parallels and the time factor. Few technical innovations would have survived the infant stage, if their complications had fully been appreciated from the outset. The difficulties adjust themselves because they create new needs which indirectly strengthen the new industry. Nobody realised what electric light and power meant, when the first electric lamps began to glow and the first electric motors to revolve. Within a few years, however, the old rivals, gas for light and coal for power, felt the beneficial influence of the competitive stimulation, and there is no reason why oil and coal should not both prosper in healthy competition.

Automobiles have become possible because fuel oils are available, and oil mining is profitable because automobiles want the oil. Mr. Freeman seemed a little alarmed because the United States have already to import oil from Mexico. That, however, is a question of reciprocal trading. If the average daily production of each American well is only four and a half barrels, the fact proves that too many wells have been drilled rather than that the actual fields are exhausted. Even if wells appear to be exhausted, so far as present methods of petroleum mining are concerned, it is quite realised that a good deal of oil is left underground. There the time factor comes in, to which Mr. Freeman did not refer. Much of the oil was probably not formed at the spot from which it is brought up. When the drilling and pumping, which enabled the gas to escape and the water to accumulate, are stopped, more oil—possibly newly-formed—may find its way into the old layers. This suggestion may, of course, be an idle speculation. New fields are still being discovered every year, and if the assessment of the world's oil supply cannot be completed for many years, this does not mean that any assessment is futile. In any case the vast deposits of oil shales and tar sands still await exploitation. It is true that the Scottish oil shale industry could not thrive were it not for the by-products of the oil, but Canada, to take an example, wants oil; her oil shales and tar sands may help to build up a chemical industry before the oil industry develops; the country will profit in either case.

The shipbuilder has to make up his mind whether to design for coal or for oil-fuel; to equip generally for either would, for the present, be too expensive. The itinerary of the ship is an important consideration. At present a steamer is more likely to find coal stores than to find oil tanks in remote ports; that will change with time. Mr. Freeman tacitly barred the use of crude oil as fuel. He distinguished between "engine fuel," the distillation product, suitable for Diesel engines, and "boiler fuel," the distillation residue, without vetoing alternative uses.

As regards engine fuel, he pointed out the engineer would like to know what kind of oil he is taking on board. Unfortunately, the oil-supplying companies will not guarantee more than "a good merchantable oil," because they have to replenish their storage tanks with oil from different tank steamers. Mr. Freeman's general specifications for a Diesel engine oil would be: specific gravity, between 0·83 and 0·92; flash point, 150 deg. F.; ash, not more than 0·05 per cent. and free of iron or silica; asphalt, less than 5 per cent.; water, not to exceed 1 per cent.; solidification point, below 21 deg. F.; gross calorific value, over 18,500 B.Th.U.; viscosity sufficiently low to admit of fuel pumping at 40 deg. F. He did not expect much trouble from the ordinary sulphur contents of the oil, which would not damage the valves, because the sulphuric acid formed would not be condensed, though it would corrode the silencers and exhaust pipes. Much of the damage attributed to sulphur he considered due to the hard asphalt, which carried the sulphur and which gave rise to hard coke deposits.

Mr. Freeman's remarks on water in the oil, its viscosity, and on the handling of the oil, were more important than his average and ultimate analyses and notes on oil refining. Water was best separated out of boiler fuel in settling tanks which should be deep and of small horizontal area; when changing over from one tank to the other, the suction valve on the second tank should be opened before the valve on the first tank was closed, lest air be drawn into the pipes. When an emulsion had been formed, oil should be heated to at least 170 deg. F. (that is higher, than the now admissible flash-point of 150 deg. F.), but then a danger might arise that any hot water drawn off might discharge explosive vapours into the engine-room. Water got into the oil from the cellular tanks in the double-bottoms which were also used as ballast tanks. Viscous oils had to be heated for circulation; cellular tanks required 1·5 sq. ft. of heating surface per ton of oil. The complete draining of the tanks was almost impossible with viscous oils. The expansion of the hot oil had to be allowed for, being about 1 per cent. per 25 deg. F. Water in engine fuel oil was best separated in centrifugal apparatus.

Legislation and the classification rules have added to the difficulties of the advocates of oil fuel on ship board. To be classed, a ship using oil has to satisfy special conditions as to structural tests, drainage, ventilation, manipulation of valves from deck, and fire-protection, including foam-producing installations, and some of the requisite appliances, Mr. Freeman states, are subject to rapid depreciation. Finally, fuel-oil prices are rising, partly owing to financial manipulation. As oil prices rise, coal prices go down, and thus a check is put on the wasteful use of oil which certainly should be suppressed. The coal and oil-fuel problems will be solved together; the solutions are yet in the laboratory stage, but the future is promising.

LONG-DISTANCE BEAM-WIRELESS COMMUNICATION.

In the early days of the use of wireless telegraphy the marked effects of daylight on the propagation of the waves was observed and attempts were made to find at what wave-lengths the disturbing actions were a minimum. Senator G. Marconi, in delivering his inaugural address on Thursday, December 11, as Chairman of Council of the Royal Society of Arts, referred to the fact that he first observed the effect in February, 1902, when experimenting with messages between the Poldhu station and a ship at sea. The results of these tests were conveyed to the Royal Society at a meeting in June of the same year and showed that although it was possible to receive messages at night up to a distance of 2,000 miles, failure was experienced during the daytime even at a range of 700 miles. Endeavours to overcome this difficulty were at once made, and Senator Marconi subsequently discovered that much longer wave-lengths than those used in the tests, 2,000 metres, would work quite as well by day as by night for transmission between England and America. For the purpose, wave-lengths of 10,000 metres or more were resorted to, and although very little experimental work was done with short waves it was universally accepted that, while they gave good results over long ranges at night, they were incapable of covering long distances during the daytime. Rapid progress was then made in the development of the non-directional wireless system making use of long wave-lengths and the results of investigations being immediately applicable to practical purposes on this system, it soon became the standard method of working.

Once the long wave-length system was established in favour, greater concentration was made on work to obtain directional wireless transmission and later to study the effects of working with short wave-lengths. It will be obvious to all that sending out waves in all directions, though valuable for naval and marine purposes, as well as for broadcasting, was singularly wasteful when messages had to be conveyed between fixed stations in a country, or between the component parts of a widespread empire. The first experiments in directional wireless were made by Senator Marconi in 1896 and described by the late Sir W. Preece in September of that year to the British Association and also by Senator Marconi the next year to the Royal Institution. Some progress was made in the succeeding years, but it was not until recent work showed the value of short wave-lengths for wireless transmission, that the system entered into the realm of practical application. During the European War investigations were started with short

wave-lengths and have continued since then. The results obtained in these tests were described by Mr. C. S. Franklin in a paper read before the Institution of Electrical Engineers in April, 1922, and by Senator Marconi to a joint meeting of the American Institution of Electrical Engineers and the Institute of Radio Engineers at New York in the early summer of the same year. As the experiments made in 1920 by Capt. H. J. Round between Chelmsford and Southend, using a wave-length of 100 metres, were so successful, two stations were erected, at Southwold and at Zandvoord on the Dutch coast, and were used for further work which proved completely successful with a power of about 1 kw. Extensions to Norway followed in 1921 and messages were sent a distance of 700 miles, when loud and constant signals were received during the night and also during the day when the barometer was low. It was during this experimental work that the curious night distortions of telephone signals were observed, the major cause of which was more recently discovered by Captain H. J. Round in his experimental work on broadcasting.

In the spring and summer of the year 1923, the steam yacht Elettra was used for further work, and the short waves used were found not only suitable for covering long distances by day and greater ones at night, but the transmission were found to be completely reliable even over large land areas and ranges of mountains. In the last twelve months the work has been extended to cover world-wide ranges between Poldhu, Montreal, New York, Rio de Janeiro, Buenos Ayres, and Sydney. In this work great success was obtained, including the first telephonic communication with Australia, when the sending station used only a power of 20 kw. The signals were received with great strength at New York, Rio de Janeiro, and Buenos Ayres during the time when darkness spread over the whole, or the major part, of the great circle track separating these places from Poldhu, but no signals at all were received when the same space was all, or practically all, illuminated by the sun. This limitation of the period of working to practically the hours of darkness constituted a disadvantage, but the economic advantages combined with the reliability and the possibility of working at far greater speeds than are possible with high-powered, long wave-length working, convinced Senator Marconi that the older method was doomed to be replaced by the short-wave-beam system, and proved an inspiration for further work. It is on this system that the stations proposed for the British Post Office, which are now in course of erection, and those in the principal Dominions and far distant countries are to be worked.

More recent work with wave lengths of 92, 60, 47, and 32 metres showed that the daylight range of practical communications over long distances increased very rapidly as the wave-length was reduced. With transmission at 32 m. messages were received all day at Beyruth from Poldhu, 2,100 miles distant over mountainous land, while the 92-metre waves could not be picked up at Madeira, a distance of 1,100 miles over the sea. Investigations conducted two months ago showed that transmissions between Poldhu and Sydney and other distant places were possible at a wave-length of 32 m., with the expenditure of only 12 kw., and for 23½ hours every day. It was also found that messages could be conveyed from Britain to New York, Rio de Janeiro, and Buenos Ayres while the spaces intervening were exposed to daylight.

The importance of this recent work in wireless transmission cannot be over-stated. Low power consumption, low capital costs and running expenses, the characteristics of the new system of short wave-beam transmission, should make possible the reduction of telegraph rates for long-distance communication, in addition to making commercially remunerative the establishment of wireless transmission to the smaller outposts of the Empire. The serious problems of financing high-powered stations for the old method of working have now disappeared, and it is no longer necessary to have high powers, such as the 1,000-kw. plant which is being installed at Rugby and those of the newly equipped stations at Buenos Ayres and in the Union of South Africa. Such stations will soon prove uneconomical and comparatively inefficient for long-distance work. It is interesting to note that in this phase of development the technical side of the work has far outpaced the theory, and we are still far from possessing anything approaching exact knowledge of the conditions governing the propagation of these waves through space. Reflectors of economical and practical dimensions are only efficiently applicable when short waves are used, and seem to be essential for ensuring the carrying out of commercial high-speed transmissions. Their use diminishes fading, and thus increases the margins between which the received signals can be read. A new era has been opened for wireless telegraphy as the result of this recent experimental work, and all who have contributed to it are deserving of the gratitude of the people of the whole civilised world.

THE 1923 TRAFFIC CENSUS.

THE seven-day traffic census of the principal Class I roads in Great Britain, taken by the Ministry of Transport in August 1922 and published earlier in the present year, revealed information of so much value alike to road engineers and road users that it was decided to take a similar census of the principal Class II roads in August, 1923, the results of which have now been published. The census of both classes of roads is to be repeated at regular intervals, and on these occasions it may perhaps be found possible to take the census of both classes over the same period in each district, so as to exhibit a simultaneous picture of the whole state of traffic. The distinction between the two classes of roads is that Class I, of which there are about 24,000 miles out of about 178,000 miles under the control of highway authorities, is intended to include the main traffic arteries, and Class II, in which there are about 14,500 miles, includes the next most important highways. The rating of these roads comes up for revision every year, and the distinction is not merely academic, as Class I roads receive from the Road Board a contribution of 50 per cent. of the cost of their upkeep, while Class II receive 25 per cent. An appendix shows how the figures of mileage of both classified and unclassified roads are made up.

In this, as in the Class I census, London and County Boroughs were excluded, leaving about 14,000 miles of Class II roads for examination, and the traffic at 3,393 points on these was enumerated for 16 hours a day during seven days in August, chosen in each district so as to exclude occasions of abnormal traffic. The vehicles were divided into 17 classes in addition to tramcars and pedal bicycles and cattle, sheep and pigs, and handcarts and barrows, conventional approximate weights for each class being used in calculating the tonnage over each point. A table shows the number of census points in each of the 61 English and 32 Scottish districts (mostly counties) over which the roads under examination ran, and distinguishes 12 grades of traffic density, mentioning for each density the percentage of vehicles that were motor-driven. A second table shows for 108 typical Class II roads chosen all over the country the maximum, minimum, and average density of traffic (tonnage), together with the percentage of motor vehicles in each figure, and the number of points along the road at which observations were made. A third table gives a complete summary of the data in regard to two of the roads, each about 40 miles long, defining the position of each census point, the width and surface of the carriage way, and the weather on the census date, the data being divided under motor cars and motor cycles, heavy motor vehicles and trailers, and horse-drawn vehicles, and expressed both as weights and as numbers. Similar records are now available for almost all Class I and Class II roads, and can be consulted at the Ministry of Transport, Roads Department, 7 Whitehall Gardens, or at the offices of the Divisional Road Engineers in Birmingham, Exeter, Leeds, Cardiff and Edinburgh. An appendix gives a specimen of the traffic records on which the census of Class II roads was prepared, one such being taken for each point; but for some reason no summary is given of these point records, from which the distribution of the traffic among the individual classes of vehicles might have been seen.

A third appendix gives the number of road vehicles in Great Britain licensed in 1923, distributed over 15 groups of vehicles, with a note of further miscellaneous receipts, which bring the income of the Road Board from Great Britain to upwards of 13,000,000*l*. The fourth appendix consists of six maps showing, for districts of about 30 miles square in different parts of Great Britain, all the Class I and Class II roads with the census points and the tonnage on each, enabling the two classes to be compared for density of traffic. These are on a smaller scale than the Ministry of Transport Road Maps, which show on the scale of half-an-inch to the mile all the Class I and Class II roads in distinctive colourings with their identifying numbers. A final appendix gives two charts comparing for 12 districts where the data are available the traffic of 1923 with that of 1912-14.

Inspection of the tables discloses some interesting results. About three-fifths of the census points in England and Wales, and about five-sixths in Scotland, showed densities of traffic below 500 tons a day; about the same figures, substituting 1,000 tons for 500 tons, had been found with Class I roads. The highest density on Class II roads found at a point in the Willesden district was over 11,000 tons a day. Only 12 per cent., however, of census points on Class II roads carried over 1,000 tons a day, as against 36 per cent. on Class I roads. The Class II roads show, on the other hand, a higher percentage of horse-drawn traffic than the Class I, and the report suggests that a still higher percentage would be found on the unclassified roads. Though pedal bicycles are not included in the average tonnages, they happen in the specimen census-point record to weigh more than half as much again as the motor-bicycles, and in numbers form from one-fifth to three-fifths of the enumerated vehicles on both Class I and Class II roads, reaching the higher percentages in the neighbourhood of populous districts, and in the neighbourhood of London, dropping sharply outside a radius of 40 miles. The charts comparing traffic before and since the war are hardly numerous enough to suggest general conclusions. Some roads show enormous increases; at a point near Wednesfield, for instance, the tonnage has been multiplied almost five-fold, and the percentage of motor-driven vehicles has increased from 55 to 94, though the absolute amount of horse-drawn vehicles has not fallen appreciably. The table of road vehicles licensed in Great Britain in 1923 is not pleasant reading when the sort of figures are remembered that a similar return for the United States would show, where more than 12 times as many vehicles are on the register.

GERMAN SUBMARINE DESIGNS.

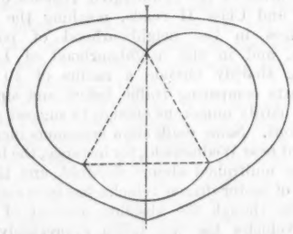
PROFESSOR Oswald Flamm has recently published a paper in the Marine Rundschau, under the title of "The Problem of Large Submarines." As his name has been connected with this very difficult question for a number of years; and as he has up till now, maintained an impassive silence upon his inventions and designs, his article is of the greatest interest. He deals with what is known as the "capital ship controversy" very shortly: "The proper view to take is that the battleship, battle cruiser, small cruiser and torpedo boat will not disappear, at all events in any foreseeable time; but it must also be admitted that technical progress will shortly give submarines a position which they do not at present possess in the hierarchy of weapons of war." The problem of increasing a submarine's fighting power hinges on the essential question of stability. "Heavy artillery and torpedo tubes can be mounted in barbette on the deck; armour plates can be fitted to the deck and the sides; stores of mines can be stowed inboard; in fact, all requirements which involve putting heavy weights in the upper part of the ship, can be complied with; but only if the vessel possesses sufficient stability."

Designers have hitherto striven to increase a submarine's stability by two methods: (i) they have endeavoured to lower the position of the centre of gravity; and (ii) they have tried to raise the position of the centre of buoyancy: both have very grave disadvantages. If the first method is adopted, masses of heavy material have to be put low down in the body of the submarine; when these

are added to counteract the weight of heavy artillery and armour fitted to the upper deck, above the centre of buoyancy, they add so much to the dead-weight in the boat, that her displacement tonnage increases uneconomically. These extra tons of ballast have to be paid for out of sea-keeping capacity, that is, at the expense of fuel supply. The second method involves an exactly opposite procedure. If attempted, water-tight, hollow chambers are placed high up in the boat, and masses of wood or cork are fitted to the upper deck. "Construction on these lines has the disadvantage of increasing weight and of using inside space to no effective purpose." Apart from this, the increase of general buoyancy compels a corresponding increase in the size of the flooding chambers. . . . There remains an alternative method: that of so shaping the hull (i) that the total space it occupies is available for useful qualities, (ii) that, on submerging, its displacement rapidly increases, and (iii) that, in all critical periods of diving, the metacentric height is sufficient.

If the boat is constructed with the ordinary circular cross section, these requirements are not attainable in a large submarine, for the following reason. The structural strength of the hull at a constant depth, has to be made proportional to the diameter of the submarine: it follows, therefore, that, if the boat is large, the requisite peripheral strength can only be obtained by making the outer structure very heavy; and if the boat becomes really large this structural weight soon reaches an unmanageable figure.

Professor Flamm's solution had better be described in his own words: "the problem, it seems, can only



be solved by giving the boat a cross section, made up of three circles, which are described round the sides of a triangle with its apex upwards (see diagram).* It is easy to understand, that, if the triangle, the radii, and the positions of the centres of the circles are correctly calculated [*lit.* selected], there will not only be a maximum of stability but the stresses along the base of the triangle, due to hydrostatic pressure, will be reduced to nil. As the component parts of the cross section are arcs of circles, the radii of which are smaller than the radius of the circle which would circumscribe the whole cross section, it follows that the structural strength of the hull required along these separate circles is less than would be required if the cross section were one single circle, with the consequence that very great strength is not necessary.

Professor Flamm designed three boats on these lines; the first, with a displacement of 1,443 tons, carried 134 tons of deck armour; the second a submarine cruiser of about 7,067 tons had 614 tons of deck and side armour, about 500 tons of heavy barbetted and lighter guns, and deck torpedo tubes; the third, a minelaying cruiser of 7,734 tons carried a thousand mines on the mine deck over the pressure-resisting part of the hull. In each case the diving stability diagram showed extraordinarily good figures, although no ballast of any kind was allowed for in the calculations.

Professor Flamm admits that it might be asked whether the military value of these large submarines justifies their construction. He considers that they may be compared with the British monitors off the Flanders coast. "If an armoured submarine with heavy artillery engages other ships with her deck awash, she is barely visible at long ranges, and can attack the unprotected parts of larger vessels, and keep them effectively under fire. It has to be allowed that a chance shot may put the submarine out of action; but the war on the Flanders coast, showed how rarely hits could be obtained even by stationary forts ashore. More than that, a large submarine's heavy torpedo armament ought to protect her from an attack at close range. The military value of the large submarine minelayer consists in her high speed, and her exceptional radius of action. She can be independent of the shore for many months; so that nobody can discover her zone of operations when once she has left her base."

Professor Flamm maintains that the British "X" class, now being built, do not overcome the defects of which his own designs are free. They have heavy deck guns; but they carry 250 tons of ballast as a compensation. "This useless dead-weight necessarily lowers speed, radius of action, and running costs; but, if this kind of construction is adopted, there is always the chance that, when the boat submerges in a seaway, the enormous moment of inertia of the upper mass, and that of the compensating ballast, placed lower down, may put her in danger. A boat's rolling period increases with an increased moment of inertia; it may, therefore, happen that the righting moment no longer suffices to bring the boat back to an even keel, if she has been rolled to a certain angle owing to her moment of inertia. This danger becomes acute when a boat is at the critical phase of submerging, that is, when the centres of buoyance and of gravity coincide." He adds the interesting remark that the British Admiralty has known every detail about his designs since 1919.

* In the diagram attached to Professor Flamm's paper the triangle was equilateral. He none the less used the term "apex upwards," "Spitze nach oben liegenden Dreiecks," showing that in his own particular designs the triangle was isosceles. He gives no clue at all as to the proportion between the lengths of the base and the side which he found most suitable.

NOTES.

The Harbour of Tripoli.

The captains of the port of Tripoli, the Signori Adelchi Moltedo and Paolo di Bartolomeo have recently published an instructive study upon the actual condition of Tripoli harbour, and its future possibilities. The development of the Guinea coast under French and British rule, and the effort to make the upper Niger more navigable, have robbed Tripoli of much of its commercial importance. For centuries it was the debouching point of three great caravan tracks, along which thousands of African slaves, and a large proportion of such central African products as ivory, ostrich feathers, amber and skins were carried. The slave trade has disappeared, and goods from the upper Nigeria and the lake Chad district now go south instead of north. The present shipping traffic figures for Tripoli are not encouraging. The number of entries is practically the same in 1923 as it was in 1902. The quantity of goods brought into the country has, it is true, increased fourfold; but this is because so much military equipment, and building material for public offices has been carried across it since the occupation. During the same period the export figures have fallen off from 67,000 tons to 26,000 tons. The chief reason for this decline is that, in 1902 esparto grass was the chief article of export; during the last twenty years wood pulp has steadily displaced this in papermaking processes. The future of Tripoli thus depends solely upon the development of the hinterland. If agriculture in the country prospers, the exports of sansa (crushed olive pulp), and various other native products, which find an easy market in the Mediterranean, may yet be considerable. The authors show how adversely the lack of good harbour accommodation is affecting the trade of the Italian colony. Not one of the other harbours—Zuara, Sliten, Homs or Misurata—gives shelter from all winds. The result is, that, as Tripoli is the only port of refuge, loading and unloading operations are frequently interrupted at the minor harbours, as small craft have often to put to sea on a change of wind, and the whole Tripoli coasting trade suffers, in consequence, from high working costs and insurance charges. The Italians have, as is well known, built a long protective mole from Spanish fort, along the Sibun Shinel shoals, and are developing the wharfage in the south-western side of the harbour, on either side of the "Pasha's Castle." The protective mole faces an unbroken stretch of 500 miles of water in a direction N15°W (true); and one of 200 miles in a direction N24°E (true). It was found, when the work commenced, that a heavy sea coming in from either direction raised waves about 17 ft. high, with a velocity of about 48 ft. per second, and that the mole would have to resist a pressure of 18 tons per square metre at the water line, and 6 tons per square metre at the top edge of the masonry. The principal weakness in the present organisation of the port is the slowness with which cargoes are lifted; for as the authors justly point out the real "coefficient of a port's capacity" is the amount which can be loaded or unloaded in a certain period of time. At the present moment steamers can only take in or discharge about 60 tons in a working day, and sailing vessels a good deal less. The present wharfage is, moreover, insufficient; during the year 1923 about 13,000 tons of import and export goods were lifted, and of these, some 4,500 tons were dealt with by lighters. It is, however, expected that the new wharves in the south-western part of the harbour will make good the deficit, as, when finished, they will give about 880 metres of additional quay space, with a yearly capacity of 214 tons per metre of wharf.

Belgian Coal-mining and Metallurgy.

Information concerning the coal-mining and iron and steel industries of Belgium during the first six months of the present year is contained in a report recently issued by the Comité des Forges de France. The coal output was 12,298,810 tons, for 149 working days, as compared with 11,127,700 tons during the same period of last year, for 145 working days. An interesting feature of the output during the first six months of the present year is that the monthly figure gradually fell from 2,182,530 tons in January to 1,848,040 tons in June last. The average monthly output is 2,049,800 tons for the period under review, as against 1,854,600 tons for the first six months of 1923, and 1,903,400 tons for the year 1913; this shows a very satisfactory improvement. Coke production reached a total of 2,151,280 tons in the first six months of 1924, as compared with 1,966,480 tons for the corresponding period of last year. The monthly average for the first half of the present year is, therefore, in round figures, 358,500 tons, which is far above the monthly average, 293,600 tons, for 1913. Coal briquettes were manufactured to the amount of 1,010,790 tons as against 987,040 tons during the first half of 1923. The iron ore imports rose from 3,387,958 tons for the first half of last year to 4,259,041 for the first six months of the current year, by far the greater proportion coming from France, namely 3,859,550 tons. The imports of manganese ore were for the first half of last year 79,757 tons, and for the first half of this year 116,416 tons, of which about 64,000 tons came from India and 25,000 tons from Egypt, the latter figure being more than double the imports from Egypt during the corresponding period of 1923. Very satisfactory figures are also given for the pig-iron production during the period under consideration; this amounted to 1,368,180 tons, the average monthly production exceeding that of 1913 by 21,000 tons. The production of steel ingots and castings was 1,414,280 tons, as against 1,051,180 tons during the first half of last year. All these figures, which are in metric tons, show the coal and iron and steel industries to be in a healthy condition.

Bauxite and Aluminium in the United States in 1923.

Owing to the increased demand for products from bauxite, particularly aluminium and abrasives, the bauxite industry of the United States improved decidedly in 1923 over 1922. The bauxite production of the country, which had diminished since 1921, increased to 522,690 long tons, valued at 3,156,610 dollars, and was thus a little larger than in 1920, though not of quite so high a value. The most striking feature about the bauxite imports was the predominant share of British Guiana, which last year shipped nearly 10,000 tons of bauxite per month, mostly via Gulf ports, to the United States. British Guiana, which had hardly

exported at all before 1917, and also Dutch Guiana, promise to become the most important sources of bauxite for America. In value the exports from the United States of bauxite, 78,560 tons, were slightly greater than the much larger imports, because they consisted chiefly of concentrates of an average value of 6 dollars per ton; more than twice that figure had occasionally to be paid. For the manufacture of refractories and chemicals increasing use is being made of crude clay. The diaspore clay from Missouri is a hydrated alumina occurring in scales or foliated masses and utilised chiefly for abrasives. The aluminium metal industry absorbed three-quarters of the minerals. The number of automobiles built in the United States rose in 1923 to a little above four millions, and every car required about 100 lb. of aluminium. The Shenandoah airship was built of 17 S alloy, consisting of aluminium with 4 per cent. of copper and 0·5 per cent. of magnesium and manganese. Castings of high silicon-aluminium alloys are coming into favour. Aluminium cables for electric power transmission had a length of 125,000 miles, and 85,000 miles of these cables were reinforced with steel. The world's aluminium production, we further see from the "United States Geological Survey Paper I: 3," on bauxite and aluminium in 1923, has greatly changed since the war. Austria had disappeared from the producing countries, the productive areas formerly Austrian, now belonging to Yugoslavia and Italy. In Germany large works are working at one-fifth capacity, and the country has had to import aluminium from Switzerland; French bauxite production also decreased, though the country continued to export to the United States. Canadian aluminium works exported in 1923 more than four times as much metal to the United States as in 1922.

The French High Naval Command.

A French decree, which cancels about ten previous laws and orders, has just been published in the *Journal Officiel*. It completely re-organises the French naval command and contains some important provisions. The executive head of the French Navy is henceforward to be the chef d'état major; he is to hold the rank of vice-admiral, and is, in the words of the decree, "to take charge of operations at sea, in conformity with the instructions of the Minister, and the general wishes of the Government." Immediately subordinate to him are the commanders-in-chief of the Mediterranean and Atlantic Squadrons, who command all the squadrons, patrols, fixed and mobile defences within their commands. The Atlantic region is, evidently, considered to be more important than the other, doubtless owing to its long coast line, and the weakness of the naval forces which are stationed in it. The organisation is therefore strengthened by a "commander-in-chief of the Atlantic coast line," who acts as an "inspector general of all naval forces intended for the defence of the coast." There is no analogous command in the Mediterranean area. These three commands exist both in peace and war; but, on mobilisation, special officers will be appointed to command all the patrol forces in the Channel, the Atlantic and the Mediterranean. It might have been thought that these would have taken orders direct from the rue Royale; but they are directly subordinated to the commanders-in-chief of the Atlantic and Mediterranean Squadrons. These arrangements complete the organisation of the naval forces afloat. Under the old system, which was in force before the present decree was published, the coast line was divided into four coastal areas, called the maritime frontiers, placed under the charge of vice-admirals with their headquarters at Dunkirk, Lorient, Marseilles and Algiers. These commands are now suppressed; and six maritime prefects take over the duties which were formerly assigned to the commanders of the maritime frontiers. Within his area, the maritime prefect has charge of all naval dockyards, and is, in addition, responsible for defending the shore line against a "floating, disembarking, or landed enemy." The coast of the prefectures is divided into sectors; and, in each, a naval officer takes command of the coast defence. These officers of sectors are, in their turn, commanded by a naval officer of flag rank to whom the maritime prefect delegates the executive command of the coast defence. The idea which dominates the entire system is evidently the one expressed in Monsieur Georges Boussenot's report, previously described in ENGINEERING: the French Navy is not, in itself, strong enough to make armed landings impossible on the northern and western coasts, and a special, amphibious organisation is necessary to meet the danger. The new decree also re-constitutes the "Conseil Supérieur de la Marine"; a consultative body which, though it has not got the constitutional position of the British Board of Admiralty, is none the less an important part of the French naval command. Henceforward, the Conseil is to be composed of: the Minister of the Marine, the chef d'état major, the commander-in-chief of the Atlantic and Mediterranean Squadrons, the commander-in-chief of the Atlantic coast line, and a vice-admiral specially appointed by the Minister. The Government and the naval executive are still free to disregard, or over-rule, advice given by the Conseil; but no decision can be taken with regard to naval programmes, general organisation, coast defence, the characteristics of units to be laid down, including airships and aeroplanes, battle tactics, or the extension or suppression of dockyards, unless this powerful naval committee has first been consulted.

The University of Leeds.

The Yorkshire College, which was founded in 1874, and was for long a constituent college of the Victoria University, was granted a separate charter as the University of Leeds in 1903. This year is, therefore, the jubilee of the foundation of the college and the twenty-first anniversary of its constitution as a University. The occasion was recognised by the holding of a series of functions this week, which served as the means of reunion of many former members of the staff and students. A thanksgiving service was held in the Leeds Parish Church on Sunday last, when the Archbishop of York officiated. On Monday morning the Chancellor, His Grace the Duke of Devonshire, K.G., with the members of the Court, senate, staff and students of every year since the foundation of the college, assembled in the Great Hall. After the opening proceedings a series of short addresses, mainly reminiscent, were given by past and present members of the University. Sir Dugald Clerk, D.Sc., who was a member of the staff in 1874, delivered the first of these addresses. In the afternoon a reception was given in the Medical School, and in the evening the University Dinner was held in the Town Hall. The Right Hon. the Earl of Balfour, K.G., proposed the toast of "the University of Leeds," at the dinner in a speech in which he urged the recognition of the true aims of a University. Addresses of Congratulations from the Universities of the Empire and from learned societies were presented on Tuesday morning, when there was a reception in the Town Hall by the Chancellor. Colonel Kitson Clark gave an interesting lecture on the foundation and early history of the Leeds Philosophical Society at a display of historical and scientific exhibits in the Hall of the Society in the evening. Other ceremonies included the presentation of many honorary degrees and visits to the various departments of the University, to give the visitors the opportunity of gauging the progress that has been made.

Explosion Hazards Incidental to the Unwatering of Coal Mines.—Several cases having recently been reported of explosions occurring in coal mines, while the mines were being unwatered or very soon after the unwatering, L. D. Truey, of the United States Bureau of Mines, investigated whether any special danger would arise when water that had been standing against the face of the coal for some time was suddenly removed, either by natural drainage or by mechanical means. The cases so far examined do not justify the general statement that there will always be an accumulation of gas whenever water backs up under a head into mine workings, but extreme care should certainly be exercised when an area is entered from which a considerable amount of water has been removed, especially when that water has been under a high head. Approved closed lights should alone be used in such areas, at any rate until a careful search for explosive gas has been made by means of a flame safety lamp.

THE LATE MR. F. J. PLATT.

An engineer who contributed largely to the modern development of internal-combustion engines, not only for power supply in works, but also for aeroplane propulsion, Mr. Francis James Platt, died at his residence, 20, Woodchurch-road, West Hampstead, on December 1. He was born in 1869 and was the son of the late Mr. James Platt, M.Inst.C.E., of Gloucester.

After leaving Cheltenham College, at the age of 17 years, Mr. Platt entered the works of Messrs. Fielding and Platt, Limited, Gloucester, and after the study of the practice of engineering in many of the shops, he became a student at Owen's College, Manchester. On the completion of his studies, he returned to the works and superintended the erection of many large plants. He then entered the design side of the organisation, was made assistant manager in 1894, and chief draughtsman in 1897. During this period he superintended the construction of a large hydraulic shipyard gantry for Messrs. Harland and Wolff, Limited, of Belfast. In 1898 Mr. Platt became a partner in the firm.

On the death of Mr. J. Humpidge, of the Dudbridge Iron Works, Limited, near Stroud, through the bursting of a flywheel in 1903, Mr. Platt replaced him as managing director. Under the new control the company made many interesting developments, and were among the pioneers in the construction of aeroplane engines. The report of the Naval and Military Aeroplane Engine Competition, 1914, shows that the firm was awarded three prizes of 100*l.* for engines of the Salmson radial type which they built. One of these engines, a 200-h.p. set, seems to have been the first of so large a power constructed in this country. The active career of Mr. Platt came to a sudden close at the commencement of the moulders' strike in 1919. On the day of the commencement of the strike he was delivering an address to the workmen when he collapsed through a seizure. Soon after this the business at Stroud was sold, and when Mr. Platt had sufficiently recovered to resume work, he opened an office in Westminster and practised as a consultant. He was a Member of the Institution of Mechanical Engineers and a past president of the Gloucester Engineering Society.

LABOUR NOTES.

If the more important trade unions, which have clearly defined their attitudes on the subject, are as good as their words, there will be trouble in Germany over the ratification of the Washington Eight-hours' Day Convention. A number of them have expressed their intention to press for ratification, and they have been assured, in most cases, of the support of the sectional Internationals to which they belong. The central committee of the Association of German Industrial and Commercial Undertakings has formally pledged itself to resist ratification. At a meeting in Berlin, on December 10, under the presidency of Herr Granz von Mendelssohn, a resolution was passed in which the Association put on record its refusal to ratify on the ground that the Convention "not only offers no advantage whatever to German economic life, but will only be increasingly harmful and dangerous to it," "The German people," the resolution goes on to declare, "must retain full freedom in regard to the number of hours they work per day, so that they can at all times ensure their existence and fulfil their obligations. So long as the burdens of the war are placed almost wholly on the back of the German people the latter cannot submit in regard to the length of time they work to the control of the countries that are competing with them.

Whether the German trade unions, backed by the other national organisations with which they are associated, are strong enough to oblige the employers of their members to ratify, remains to be seen. In view of this avowed attitude of hostility by so strong a body of foreign employers it would, obviously, be foolish of Great Britain to ratify. The stock argument here is, of course, that if we ratified, all the other parties to the Convention would follow the lead; but the likelihood is greater, human nature being what it is, that the example they would follow would be that of Germany. We adhere to the view that if there is to be ratification it ought to be general and unconditional, and that the law ought to be given effect simultaneously in all countries.

The United Society of Boilermakers and Iron and Steel Shipbuilders is not now, of course, a unit of the Engineering and Shipbuilding Trades Federation, but when the Lifton House executive decided to apply for an increase of wages it was regarded as a foregone conclusion that the Federated Trades would eventually follow the lead. They have now, as a matter of course, resolved to do so, and as their example is most unlikely to be lost on the other unfederated trades the negotiating committee of the Shipbuilding

Employers' Federation will have its time pretty fully taken up with conferences in the New Year. The argument that the state of trade justifies the increase demanded should not take much time to dispose of if the representatives of the men have not forgotten Sir William Mackenzie's award on the last reference. In the course of that award—which was issued as recently as June 6 last—Sir William said that in an endeavour to keep the industry going the employers had entered into contracts without thought of profit and in some cases with the certainty of direct loss. On 59 contracts on new work completed by members of the executive committee of the Shipbuilding Employers' Federation since June, 1922, the sum of 233,000*l.* had been lost, and on 83 contracts on new work not yet completed it was estimated that, on the basis of the continuance of the present wages, there would be a loss of 785,000*l.* These figures were startling, Sir William said. The yards being only partially employed, the employers had incurred further liabilities. It was not to be understood that these contracts were a speculation which turned out badly; they were undertaken in many instances with a view to keeping the industry alive. There was, it was added, no parallel in the history of the industry to the current depression.

On the showing of the foregoing figures, further heavy losses must have been incurred on contracts in progress at the time the award was made. Nor between then and now has there been a sufficient improvement in ship prices to off-set the increase awarded. These are statements which anybody can verify for themselves by studying the published records of new tonnage prices. The effect of a wages increase of 10*s.* per week—which would mean approximately an addition of 10*s.* per deadweight-ton on an ordinary cargo vessel—must, therefore, be to check any tendency which the industry is showing towards revival.

As was expected, the representatives of the engineering trades unions, who met at York last week, for the purpose of considering the further steps which should be taken in support of the application for an advance of wages, decided to seek another conference with the Engineering and Allied Employers' National Federation. The expectation is that such a conference will take place early in the New Year. How far the subcommittee of union representatives, which was appointed to deal with Sir Allan Smith's figures, has carried its investigations, is not known outside the circle most intimately concerned; but it is tolerably clear that unless the statistical summaries given by the chairman of the employers' management committee are convincingly demonstrated to be wrong, the arguments in favour of an advance of wages will have no substantial foundation.

A decline of 8,354 in the number of unemployed persons is officially recorded for the week ending December 8. According to the Ministry of Labour, the number of unemployed men on the registers of Employment Exchanges in Great Britain decreased from 910,162 on December 1 to 907,700 on December 8, the number of unemployed boys from 30,990 to 29,400, the number of unemployed women from 221,805 to 218,800, and the number of unemployed girls from 27,297 to 26,000. The total number of unemployed persons is 1,181,900, as compared with 1,190,254 on December 1, 1924, and 1,285,623 on December 31, 1923.

The *Ministry of Labour Gazette* states that employment showed little change, on the whole, during November. There was a considerable further improvement in the cotton industry, but a marked decline in the tinplate trade. In other industries the changes recorded were generally slight. Among the 11,500,000 workpeople insured against unemployment under the Unemployment Insurance Acts in Great Britain and Northern Ireland, the percentage unemployed at November 24, 1924, was 11, compared with 11·1 at October 27 and with 11·5 at November 26, 1923. Among the members of those trade unions from which returns were received the percentage unemployed was 8·6 at the end of November, 1924, compared with 8·7 at the end of October, 1924.

Employment was good, on the whole, in the steel sheet, brick, carpet, and jute trades, and with most of the skilled operatives in the building trade. It was fairly good in the silk trade, with millsawyers, and in most branches of the printing trade, and fair in the furnishing, leather and pottery trades, and in certain sections of the metal trades. In the coal-mining industry it was still slack; at iron and steel works and in the engineering and shipbuilding trades it continued bad. In the industries for which statistics are available the changes in rates of wages reported during the month resulted in an aggregate increase of about 50,000*l.* in the weekly full-time wages of 690,000 workpeople, and in an aggregate reduction of about 3,500*l.* in the weekly wages of over 60,000 workpeople. During the eleven completed months of 1924, the changes reported to the Department have resulted in net increases equivalent to over 580,000*l.* in the weekly full-time wages of 2,850,000 workpeople, and in net reductions of nearly 64,000*l.* in those of 500,000 workpeople. In the corresponding period of 1923 there were net reductions of nearly 480,000*l.* in the weekly full-time wages of 3,000,000 workpeople, and net increases of nearly 170,000*l.* in the weekly wages of 1,200,000 workpeople.

During the first 11 months of 1924 the stoppages of work owing to trade disputes reported to the Department have involved approximately 597,000 workpeople as compared with 386,000 workpeople involved in the first 11 months of last year. The aggregate duration of the stoppages in January to November, 1924, has been about 8,223,000 working days, as compared with about 10,535,000 days in the corresponding period of 1923.

Until the question of the mileage basis for enginemen is adjusted it is unlikely that much progress will be made by the railway managers in their consideration of the new programme submitted by the National Union of Railwaymen and the Railway Clerks' Association. Until the proposals have been analysed by those who are most competent to carry out such a task it would be idle to frame an estimate of the probable cost to the railways—and eventually, of course, to the community—of the men's demands; but whatever the cost may eventually be found to be, it is certain, on the face of things, to be heavy. It is assumed that the programme will go in due course to the National Wages Board. A large part of it may, but complications appear to be inevitable over the shopmen's claims. There is no provision in the Act of 1921 for dealing with the shopmen, whose claims—which are championed by both the craft unions and the unions of semi-skilled and unskilled men, as well as by the National Union of Railwaymen—must, in the event of failure to agree, be referred to the Industrial Court which has already heard many references affecting workers belonging to these particular classes.

In November the membership of the Amalgamated Engineering Union increased from 244,451 to 244,473. A decrease was recorded in the number of unemployed persons, but the percentage is still high, viz., 7·95. In the course of a retrospect, Mr. Brownlie, the President of the Union, says that the payment of Donation Benefit is receiving the earnest consideration of the Executive Council, who are hopeful that, with improving financial resources and a revival in trade, this benefit will again, to some extent, be paid to members during the coming year. Whether it is paid or not will, however, depend upon the efforts of members in the workshops. The Council earnestly appeal to the members, individually and collectively, to do all that is possible to restore the prestige of the union to its former level by enrolling all eligible workmen as members, and thus enable the organisation speedily to secure a much-needed advance in wages to operative engineers.

In the "Monthly Report" of the United Society of Boilermakers and Iron and Steel Shipbuilders, the General Secretary states that there was a little improvement in trade in November. Many members of the organisation are finding employment, although in many cases the jobs are of short duration. Members "signing the books" at the end of November numbered 20,673 as compared with 21,467 at the end of October. The expenses for October were 102,719*l.* 12*s.* 1*d.*; in November they amounted to 95,374*l.* 15*s.* 10*d.*

Mr. Samuel Gompers, who has died in his 75th year at San Antonio, not only founded but, as president, built up the organisation which the world knows as the American Federation of Labour. Unlike the Knights of Labour, which it superseded, the Federation of Labour was an alliance of separate trade unions, and that fact, no doubt, more than any other, explained its rapid rise. Mr. Gompers was its first president, and every year thereafter, with a solitary exception, he was re-elected to the high office. He never had any sympathy with Socialism. On the contrary, he rarely neglected an opportunity publicly to condemn it. On one occasion he summed up his opinion of Socialists tersely in these words, "Economically, you are unsound; socially, you are wrong; industrially, you are impossible." For the greater part of his life he was strongly opposed to the formation of a Labour Party in American politics, preferring to bring the influence of the Federation to bear upon the Republicans or the Democrats as expediency suggested. Latterly, however, his views on the subject seem to have undergone a change. At any rate, both he and the American Federation of Labour were associated with Mr. Johnston of the International Association of Machinists, and other prominent trade unionists, in the support of Mr. La Follette's candidature for the presidency of the United States—which is generally regarded as American Labour's début in politics. Mr. Gompers, who did much fine work during the war, was widely esteemed for his sincerity, and he was always loyal to the highest ideals of organised Labour.

Whatever view the General Council of the Trades Union Congress eventually takes of the action on the unity question of its delegation to Russia, the rank and file of British organised labour are bound to be sore on one point. Whether the Amsterdam International—in other words the International Federation of Trades Unions—holds together or goes to pieces, is probably not a matter which gives them much real concern. The suggestion that as a preliminary to world trade union unity British organisations should scrap their existing constitutions and adopt that of the Third International—otherwise the Red International Labour Union—is practically certain, however, to be resented, no matter what view of the matter is taken in the movement's high places. These constitutions are not, in the majority of instances, arbitrary affairs drawn up for the most part by theorists. They have been evolved through years of practical experience in the organisation of workers by workers themselves who strongly believe in them. World trade union unity is, no doubt, extremely desirable, and Mr. Purcell and his colleagues did not err in trying to promote it. But if the compromise which they had in their minds when they made their reported arrangement with Moscow involves the radical departures indicated in Russian messages, from the established principles of British Trade Unionism, they have erred grievously in their interpretation of the views of their own rank and file.

CONTRACTS.—Messrs. George Green and Co., Foundry Engineers and Contractors, of Keighley, are this month shipping a complete foundry iron melting outfit for the new works of the Portuguese State Railways, at Lisbon. The plant consists of one of the firm's "Economic" cupolas fitted with drop bottom and receiver, large self-contained charging platform with roof, direct coupled motor fan for supplying the blast, a 1-ton electric lift and sand and coal dust mills, &c.—Messrs. Clayton Wagons Co., Limited, of Lincoln, have just made their first delivery of cars to the London and North Eastern Railway Company in connection with a contract secured by the Lincoln firm recently.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—A comprehensive collection of papers is included in the Transactions of the Institution of Engineers and Shipbuilders in Scotland for the sixty-seventh session, 1923–24, just published. A contribution on auxiliary machinery for Diesel-engined vessels, by Mr. Archibald Rennie, gives evidence in support of the use of electricity in place of steam as a means of operating such machines. In a paper on pipe bending by machinery, Mr. C. R. H. Bonn investigates the theory of tube bending and gives details of a machine suitable for work on cold-drawn steel pipes. The sliding cylinder, double-acting, two-cycle Diesel engine is discussed by Mr. J. C. M. Maclagan, while Mr. Frank R. Blair examines the Board of Trade Regulations as affecting merchant shipbuilding.

ACCIDENTS IN UNITED STATES METAL MINES, 1923.—According to the statistics of the Department of the Interior of the United States, the metal-mining industry employed, in 1923, 123,279 men, or 17 per cent. more than in the previous year; and the volume of their work, amounting to 36,559,805 man-shifts, represents an increase of 25 per cent. The number of work days was 297, against 276 in 1922. The death-rate was the lowest recorded, namely, 3·01 per thousand men employed, calculated on a standard of 300 work days, but the injury rate continued to rise to 275. The number of killed was 367, that of injured (*i.e.*, incapacitated for a day or longer) was 33,563; the highest fatality rate of recent records was 4·45 in 1911. The reduction in fatality cases was striking in the iron and in the gold and silver mines. The main causes of accidents were falls of roof or side, haulage plant and explosives.

CITY AND GUILDS OF LONDON INSTITUTE.—A careful analysis of the results of the various examinations held throughout the world during the session 1923–24 by the Department of Technology of the City and Guilds of London Institute, is contained in a report issued from the office of the Department, 29, Roland-gardens, London, S.W. 7. Compared with the preceding year the number of candidates for examination in technical subjects in Great Britain and Ireland decreased from 8,707 to 8,578, while the percentage of successful candidates decreased from 68·1 to 65·4. A feature of the year was the extension of examination facilities to the Government Technical School at Insein, Burma, for the first time, and the formation of a centre at Madras, India, under the authority of the Principal of the Government Trade School. Further, candidates were examined at Kigoma, East Africa; Abbassia, Egypt; and Mauritius, amongst other less-known localities, thus testifying to the value of the certificates of the Institution.

GEARED TURBINE MACHINERY FOR THE SS. "DROTTNINGHOLM."

IT is common knowledge that in the early days of turbine ship propulsion certain sacrifices had to be made, both in propeller efficiency and in turbine efficiency, in order to secure a rate of shaft revolution which would not be excessively high for the propeller or excessively low for the turbine. The difficulty of effecting a reasonable compromise in this matter, was the greater the slower the ship. It followed, therefore, that direct-driven turbine propellers were out of the question for cargo boats, and that, even in the case of the intermediate transatlantic steamers, running at but moderately high speeds, the turbine offered few, if any, advantages over the reciprocator. Nevertheless, thanks to the enterprise of our shipping companies, a certain number of this class of steamship were equipped with steam turbines. One notable example was the ss. Virginian which was launched by Messrs. Alex. Stephen and Co, Linthouse-on-Clyde, in 1905, and supplied with direct coupled turbine machinery by the Parsons Marine Steam Turbine Company, Limited. This vessel gave satisfactory service for many years, but was sold in 1918 to the Rederi Aktiebolaget Sverige-Nordamerika, Gothenburg, who, in view of the great progress made in marine engineering since the launch of the boat, determined to replace her original machinery with geared turbines, and also to equip the boilers for the use of oil fuel. The contract for the new turbines was let to the Aktiebolaget de Lavals Angturbin, Stockholm, in June, 1921. The trials were run in May, 1922, and the ship has since been in regular service to New York.

A general view of one of the new turbines is reproduced in Fig. 1, page 834, whilst Fig. 2 shows one of the sets of gearing. The main features of the new equipment will, however, be most easily grasped by reference to the illustrations given on Plate LXXXII. The three-shaft arrangement, characteristic of the original plant, has been retained, but the speed of the propellers has been reduced from 300 to 200 r.p.m. The propellers have also been increased in diameter, as much as the spacing permitted; and this has led to some improvement in propeller economy.

The general arrangement of the machinery room remains much as before (see Figs. 9 and 10). The central shaft is, as formerly, driven by a single high-pressure turbine, which exhausts into two low-pressure turbines, each of which drives a wing shaft. The old condensers have been retained, and, as before, the low-pressure exhaust pipes are led away from the top of the turbine casing, and not below, as is now generally practicable when geared turbines are being fitted *ab initio*.

Fig. 11.

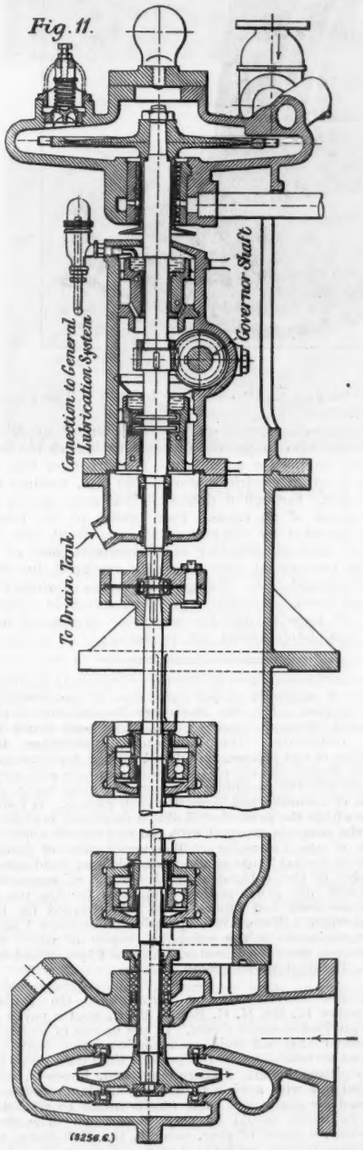
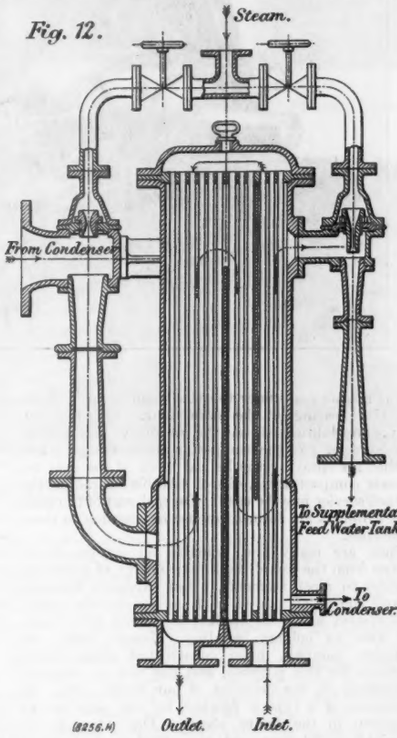


Fig. 12.



An end view of the high-pressure turbine is represented in Fig. 3, and a longitudinal section in Fig. 4. As will be seen, this turbine has six simple impulse wheels, 1·05 meters in mean diameter, the first of which works with partial admission. The designed speed is 2,400 r.p.m. or about eight times as great as that of the direct coupled turbines, with which the ship was originally fitted.

The steam from the main steam valve enters a nozzle-valve chamber. Part of it passes directly to the permanently open nozzles in the lower half of the casing, and the remainder through hand-operated valves in the upper half of the casing, by means of which an overload of 20 per cent. can be taken. The number of nozzles in use is adjusted according to the speed of the ship. The diaphragms between the wheels are of cast-iron and are slightly dished to increase their rigidity. The diaphragm packings are of the elastic type, being capable of yielding should the shaft whip for any cause. They are assembled with no initial clearance but allowed to wear their own in actual running. The main glands are carbon packed. The designed maximum discharge pressure from this turbine at full load is about 30 lb. per square inch, and, as shown in Fig. 4, a whistle is provided which sounds a warning should the pressure here (which, of course, is that of supply to the low-pressure turbines) exceed 32 lb. per square inch. The thrust block is of the ordinary multi-collar pattern, which is adequate as the axial load is very small. An emergency governor of the usual spring-loaded bolt type is provided, as shown in Fig. 3. Should the speed become excessive, the end of the bolt protrudes and trips the pawl shown, thus releasing a spring-loaded valve on the oil-pressure line. When this valve opens, the oil pressure is destroyed, and the valves supplying steam both to the high-pressure and to the low-pressure turbines are automatically closed by their relays.

An ordinary governor is also fitted. This is of the ingenious de Laval type, in which the weights pivot about knife edges and are held in place by springs, all bolts being dispensed with.

As will be seen in Fig. 9, the high-pressure pinion is located at the very top of the reduction gear-box. This pinion is of the double-helical type and is shown in position in Fig. 6. The propeller-thrust block is fitted at the forward end of this gear-box and is of the Michell type. A shaft extends from it underneath the high-pressure turbine to its forward end (see Fig. 4), and drives there a tachometer and a revolution counter. A direction indicator is also fitted here, showing whether the propeller is revolving "ahead" or "astern," and there is also an indicator which shows the axial position of the thrust collar.

A section through one of the low-pressure turbines is represented in Fig. 5, which shows that an astern turbine is provided within the same casing as the ahead turbine. The latter has six wheels, ranging in mean diameter from 145 cm. at the high-pressure end to 140 cm. at the last wheel. The steam is supplied from the high-pressure exhaust through oil-controlled valves, which open and close in unison with the main steam valve to the high-pressure turbine. A hand-operated overload valve is fitted as shown in Fig. 5, by which the first wheel can be by-passed. The exhaust steam from the auxiliaries enters the low-pressure turbine at the first compartment, where the designed pressure is 7 lb. (gauge). The reverse turbine consists, it will be seen, of one velocity compounded wheel, followed by a simple impulse wheel. The velocity wheel is constructed in two parts, with the object of reducing weight and facilitating heat treatment of the steel.

The pinions driven by the low-pressure turbines are situated on one side of their respective gear-boxes, as indicated in Fig. 9. A section through them is reproduced in Fig. 7, and one through the main spur wheel in Fig. 8. In this case the tachometer, revolution counter, and indicators are mounted directly on the gear-box, as indicated. As in the case of the high-pressure gear, the reduction ratio is 12 to 1, the turbines running at 2,400 r.p.m. and the shaft at 200, at which each propeller shaft transmits 3,000 h.p.

The manœuvring gear, with but slight modifications has been retained in the new arrangement. A steam separator has been added, and connections have been made to the various oil-pressure-operated valves. The condensers, which have each a cooling surface of 8,250 sq. ft., have been retained, but have been moved nearer to the hull. The wet-air pumps and the Parsons' vacuum augmentors have been replaced by two-stage steam ejectors for the air, and by centrifugal pumps for the condensate (see Fig. 11). Each condenser has both one steam-turbine-driven and one motor-driven pump, the latter being used for ordinary running. A section through the air ejectors is reproduced in Fig. 12. Three ejectors of the two-stage type are provided, one ejector being used as stand-by for both sides. The stand-by ejector is simpler in design, and is less economical than the others, the intermediate condenser shown in Fig. 12 being omitted. The ejectors are all of the Westinghouse-Leblanc pattern, but the special arrangement of intermediate condenser shown in the figure is due to the A. B. de Lavals Angturbin. The main condensate is used to cool the steam-air mixture from the first stage by means of the small surface condenser shown. Only the condensed ejector steam is passed into the main condenser; whilst the cooling medium that has absorbed the heat of the ejector steam is taken direct to a supplementary tank which discharges to the hotwells. By this arrangement the heat loss in the intermediate condenser is only a fraction of that of a jet condenser. The mixture from the second stage of the ejector is also led to the supplementary tank, wherein the steam condenses and the air passes off.

The steam-driven auxiliaries exhaust into a closed system, the back pressure being 7 lb. per square inch. The feed-water heater and the low-pressure turbines are connected to this closed system. When the emergency governor operates the surplus steam from the closed exhaust is admitted to the condensers. As long as any auxiliary steam is available, the pressure in the closed exhaust system remains at a predetermined and practically constant value. The glands of the main turbines are, as already indicated, sealed with steam from this closed-exhaust system, and provided the necessary minimum quantity of steam is available, the sealing of the turbine glands is independent of all manœuvring operations.

The oil supply system is entirely new, and is much larger than the original, since the geared machinery uses a larger quantity of oil. Two Weir-type oil pumps have been installed, together with two emergency gravitation tanks.

The new turbines, with their gears and auxiliary

machines, weigh 50 tons less than the machinery replaced. The steam consumption is reduced; only 7 boilers (total heating surface 24,000 sq. ft.) are required, instead of the 9 boilers (total heating-surface 30,800 sq. ft.) required previously. The gain in space has been utilised for two settling-tanks, and for the oil-burning auxiliary machinery. As fuel is now carried in the double-bottom, it has been possible to extend the refrigerating-compartment and the accommodation.

Results calculated from readings of the steam pressures made on the trial runs show that the high-pressure turbine developed 3,998 shaft horse-power, and the low-pressure turbines together 6,040 shaft horse-power. Readings taken with an optical torsion-meter applied to the centre shaft showed a horse-power of 3,987.

During the trial runs it was found that the admission valves, through which auxiliary exhaust-steam passes to the low-pressure turbine, were not working properly. It was discovered later that on account of a defective shut-off valve, the surplus steam from the heater escaped, through a safety-valve, to the funnel. Modifications of the connections between the condensers and the air-ejectors made an improvement of $\frac{3}{4}$-in. in the vacuum. The guaranteed maximum horse-power of 10,800 has now been exceeded.

A comparison of the fuel consumption figures is interesting. With the original machinery, about 2,400 tons of coal were consumed for a single journey made at a mean speed of 14·2 knots. After the ship was re-engined the oil consumption amounted to 950 tons at 16·3 knots mean speed. Assuming that 5 tons of oil were equal to 8 tons of coal, and reducing the consumption figures to the same speed, the net gain shown is 50 per cent. It has been possible to verify this. During one run the ship on leaving New York had the side propellers damaged by striking a heavy piece of timber. The injury caused to the port propeller was slight and did not prevent it being used, whereas the condition of the starboard propeller made it necessary to shut down this low-pressure turbine for the journey. The circumstances were thus rather unfavourable; nevertheless the oil consumption was still only about 50 per cent. of the corresponding coal consumption with the old machinery at the same speed, the weather conditions being practically the same.

LARGE-POWERED ROLLING MILL DRIVES.

The obtaining of suitable drives for heavy sheet rolling mills is not free from difficulty because the powers required are large and whatever means may be adopted must give the desired speed for the rolls. Electric motors have many advantages over other sources of power for the driving of almost every type of machinery and it is natural, therefore, that endeavours have been made to apply the method to this particular case. That successful work is being done in this direction is well known, and during a recent visit to the works of Messrs. Scott and Hodgson, at Guide Bridge, near Manchester, we had an opportunity of seeing an excellent example of such application. At that time there was in course of completion an electric driven gear for a rolling mill drive and a heavy flywheel for use on the Ilgner system to balance the load on the electric motor, which otherwise would be subject to violent changes in the demand for power.

The gear drive will at first be used to transmit the power from an electric motor of 2,000 brake horse-power made by the Metropolitan-Vickers Electric Company, Limited, but has been designed to deal with much greater powers, with which it probably will be used later on. Actually it has been designed to deal with normal loads of 5,060-h.p. overloads up to 10,000-h.p. and occasional peak loads of 15,000-h.p. From this it will be gathered that the gear is among the largest ever constructed for its purpose in this country. The pinion and gear wheel were manufactured for the builders by The Power Plant Company, Limited, of West Drayton. From the electric motor, which runs at 245 r.p.m., the drive is taken by a shaft 16 in. diam., on which the pinion and two flywheels of 16 tons each are assembled. The large gear wheel is about 17 ft. diam. and 4 ft. width of face and has teeth of the double-helical type. A barring motor of 50-h.p., running at 575 r.p.m., is part of the equipment and drives the barring pinion through double-reduction gearing. This is put into action immediately before the main motor is started, and when the speed of the pinion-shaft attains a higher value than that obtained from the barring motor, an automatic disengaging gear throws the latter out of action. Lubrication is obtained from separate pumps for the bearings of the pinion shaft, those of the wheel shaft and for the spraying of the wheel teeth. For the high-speed shaft of the gear, oil is supplied at a pressure of 150 to 200 lb., and is forced into the bearings below the centre line of the shaft at one side and passes through wide shallow grooves. By this system, a film of oil of $\frac{1}{1000}$-in. thickness is maintained under the shaft and keeps it floating. The bearings of the main shaft, which is 24 in. diam., are lubricated on the ordinary pump-circulated system. As the sumps for the bearing oil and for that for spraying the helical teeth of the gear are separate compartments, oils of suitable characteristics for each service may be used. On each end of the main shaft wobblers are formed for use in coupling to those of the rolls.

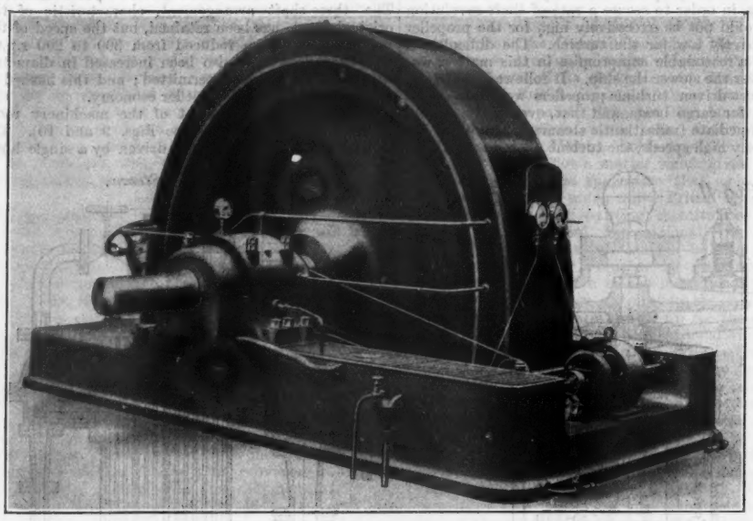
There are many and valuable advantages to be derived from the use of the kinetic energy of a rotating flywheel to meet momentary but excessive demands on any source of power, such as an electric motor. This system has been applied to rolling mill drives, and also to colliery winding. Messrs. Scott and Hodgson, Limited, have constructed many heavy flywheels for this purpose, and one was in course of completion on the occasion of our recent visit. An illustration of a typical flywheel for the same service is shown in the figure above. This example has a weight of 32 tons and is a built-up and bolted structure. The lubrication and brake systems are identical with the one at present in the works. The flywheel, now approaching completion, is made with a spider forced on to the shaft and with the rim formed of two side rings connected together by a spigot joint. By this method of construction wheels of up to 60 tons to 70 tons may be built, but the weight of the one we are concerned with is 35½ tons. It has a diameter of 12 ft. and runs at 600 r.p.m. The shaft is 14 in. in diameter, and is accommodated in bearings 28 in. in length.

The type of layout will be seen from the illustration. The bedplate at each side forms the oil sump and contains a strainer and a cooling system, by means of which the oil temperature may be reduced by the circulation of cold water in pipes. On each side of the flywheel there are two oil pumps, the first on each side having a direct drive from an electric motor for use in starting, while the others are belt driven from the flywheel shaft. These pumps are of the geared type, and are capable of maintaining an oil pressure of 150 lb. to 200 lb. Here, as in the case of the pinion drive previously mentioned, the shaft is kept floating on an oil film, and it is for the purpose of creating this at the start that the motor-driven pumps are necessary. A feature of interest is the brake suspended below the flywheel and operated by means of the hand wheel seen in the illustration. This brake has a heavy steel band lined with Ferodo. In actual use care has to be taken to absorb the energy of the rotating flywheel very gradually, and consequently a stopping period of no less than a quarter of an hour is suggested as a minimum. The brake is of such strength as is requisite to make possible the lifting of the flywheel from the bottom pedestal steps so that the bearings may receive attention whenever necessary. It is of interest to note to what a degree of precision the balancing of these wheels is carried. When it is stated that such a weight as ½ oz. will make a wheel weighing 35½ tons turn until the added load is at the bottom of the wheel, the degree of approach to absolute balance will be appreciated.

In the same works on the occasion of our visit there was also in process of construction an electric winding engine for a colliery. The drive for this is taken from an electric motor of 250 h.p., running at 730 r.p.m., through a double helical gear, giving a final speed of 66 r.p.m. Post brakes of the usual type, operated by compressed air, are fitted, but an entirely new overwinding and overspeed gear of a purely mechanical type, recently designed by the makers, is installed. This gear, by means of which the desired speed, at every stage of operation is obtainable, we hope to describe when the equipment has been completely tested out at work.

32-TON FLYWHEEL FOR ILGNER SET.

CONSTRUCTED BY MESSRS. SCOTT AND HODGSON, LIMITED, MANCHESTER.



Gauge Testing at the National Physical Laboratory.—A pamphlet giving particulars of gauge-testing work carried out in the Metrology Department of the National Physical Laboratory has just been issued by that Institution. The Laboratory undertakes the checking of end gauges, cylindrical gauges, taper gauges, profile gauges and templates, position gauges and screw gauges, and the pamphlet mentions, in most cases, the limits of accuracy laid down for such gauges. If found to be within the prescribed limits, a certificate is granted and the gauge is stamped with the well-known approval mark of the Laboratory. The verification of gauges made to special limits is also undertaken at Teddington, as also is the calibration and testing of measuring machines and gauge-testing appliances for the use of manufacturers and others. The fees charged for the work, which will come into operation on January 1 next, are mentioned in the pamphlet, copies of which are obtainable from the Director, National Physical Laboratory, Teddington, Middlesex.

Junior Institution of Engineers.—On Friday, December 12, Mr. H. G. Bouly, B.Sc., read a paper on "Fluid Transmission Gears," in the course of which he remarked that all fluid transmission gears that had proved successful up to the present time used oil as the transmitting agent. Experiments had, however, been carried out with a view to developing steam and compressed air gears, and some results might be published shortly which would be very interesting. The three well-known types of gear, namely, the Hele-Shaw, the Williams-Janney, and the Lentz, all made use of oil as the working fluid, and although differing as to the method of obtaining the final result, they could all three be said to have a common basis. They all embodied a pump by means of which the working fluid was put under pressure and transmitted to some kind of motor, where this pressure was converted into useful work. The use of oil kept friction to a minimum, and therefore gave a very high efficiency, while the apparatus would continue to work without wear for an almost indefinite period. After describing in detail the principles of the three types of gears, the author remarked that the application which was of greatest interest at the present time was that to locomotive work. The reason that internal-combustion engine locomotives had not largely been made use of had been that great difficulty had been experienced in finding a suitable mode of transmitting the power of the engine to the wheels. It was confidently expected that a complete solution to the problem would be found in a gear of one of the types mentioned.

THE COLLET FOLDING BOAT.

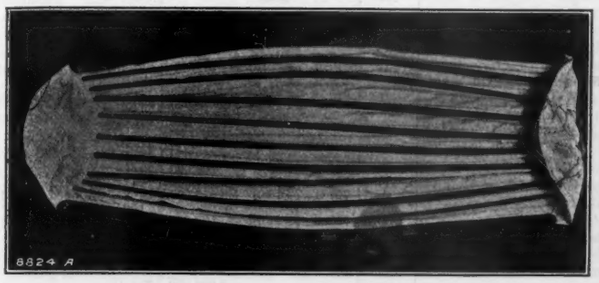


FIG. 1. SKIN READY TO RECEIVE EXPANDING FRAME.

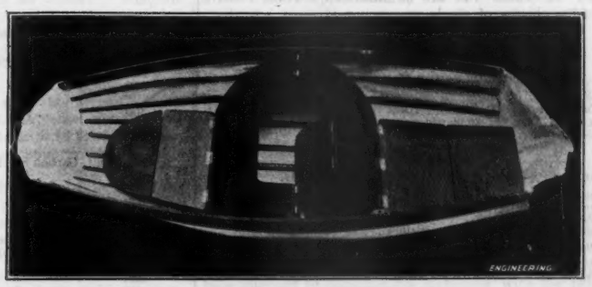


FIG. 2. EXPANDING FRAME IN POSITION PRIOR TO ERECTION.

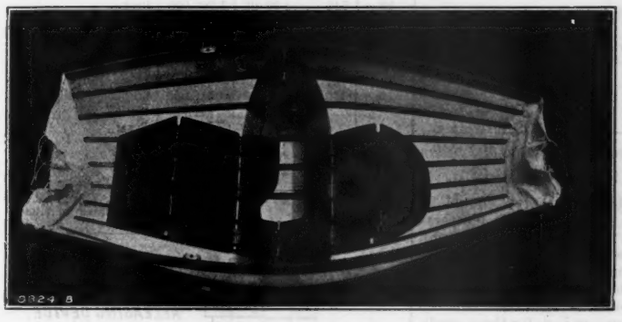


FIG. 3. EXPANDING FRAME AFTER ERECTION.

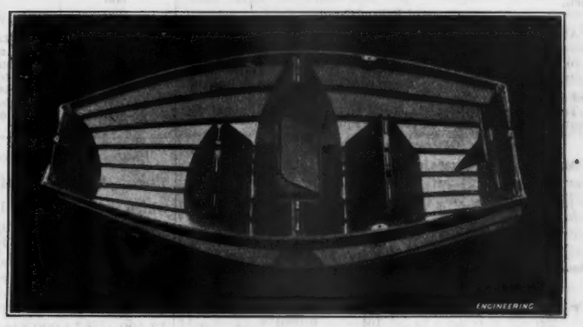


FIG. 4. THE BOAT WITH TRANSOMS IN PLACE.

THE COLLET FOLDING BOAT.

A COLLAPSIBLE boat, to be of real use, must be buoyant and stable, especially in a seaway, and in addition to being light and easily rigged or folded from the deck or cockpit of the smallest yacht, must be capable of being readily stowed into a small space. In the boat here described the first of the foregoing conditions is fulfilled by having it in the form of a Norwegian "Pram" dinghy, and from a little distance it cannot be distinguished from one. However, it has more wholesome bilges and a greater depth than most Pram dinghies commonly seen.

The 7-ft. model has a beam of 3 ft. 7 in. and a depth of about 18 in. With an average person inside it draws 5 in. of water, so that it is possible to step out dry shod when landing on the most shelving beach. This size will carry three grown-up people at a pinch, and it is possible for one person alone to stand on the extreme outboard edges of the floor boards without the boat capsizing. It can easily be rigged or collapsed single-handed on the smallest yacht in something like 3 minutes, and has without difficulty been unrigged on the diminutive counter of a 2-ton cutter whilst she was being sailed at sea with the lee rail awash. It has been tested in various localities and under all sorts of weather conditions for the last two years and proved to be efficient.

The boat consists of four units, viz.: the skin, the transoms and the thwartships expanding frame, all of which are detachable from one another. But it could also be made to consist of but two units, namely, the skin and a combination of the transoms and expanding frame. The four units will be easily distinguished in the views of the boat in various stages of assembly given in Figs. 1 to 4 above. The skin is constructed so that it can be rolled up, and for this reason consists solely of canvas and a number of light longitudinal strakes of wood, which are placed in pairs—inside and out. There are eleven pairs of these strakes, as shown in Fig. 1, the canvas being clamped between the inner and outer members of each pair, which are secured to one another by screws only, for purposes of repair. This unit can, therefore, be laid out approximately flat or rolled up into a straight parcel.

The transoms and expanding frame are secured to the gunwale strakes of the skin, which are of a much heavier section than the others, by special hook and eye fittings. The transoms are in addition locked to the middle, or keel strake when in position. The thwartship expanding frame consists of two similar panels of wood of the same shape as the transverse section of the boat. Their top edges are hinged to one another, and the pins of the hinges are formed into hooks which engage the gunwale strake fittings. Their bottom edges are connected with a light tackle. These panels are cut away in the middle to accommodate the rower's seat, which rests on both panels and is hinged to one of them. The floor boards are also hinged to the expanding frame and with it form one unit. These arrangements will be clearly followed from Figs. 2 to 4.

To erect this boat the expanding frame is opened right out, on top of the unfolded skin, and its hooks made to engage the gunwale fittings; this can be accomplished without effort whilst the frame is in the open position. The floor boards are up to this stage kept folded against the panels by means of wooden buttons, but they are now opened out and the bottom edges of the frame drawn together by means of the tackle until the canvas is quite taut, the panels by this time making an included angle of about 45 deg.

When collapsed the skin rolls up into a perfectly straight parcel equal in length to that of the boat and 7 in. or so in diameter. The other units form, in their bag, a parcel 6 in. in thickness, its other dimensions being the beam and depth of the boat.

The 7-ft. model weighs about 50 lb., this weight being dependent upon the kinds of wood and canvas used. For special purposes, such as a seaplane tender or lifeboat, for instance, it would be possible to keep the weight down to something like 35 lb. Apart from the advantages claimed for this boat in its stability, buoyancy and carrying capacity for overall length, stowability and lightness, the ease and rapidity with which it can be rigged and folded from the deck or cockpit of a small yacht, is a feature of great value. The boat is likely to show good lasting qualities, owing to the protection given to the canvas by the outer strakes, and the ease with which the wooden strakes of the skin can be replaced when worn out or broken. The self-adjusting properties of the expanding frame make it as easy to rig the boat in wet weather as in dry. The boat is due to and is the patent of Mr. F. J. Collet, of Old Bursledon, near Southampton.

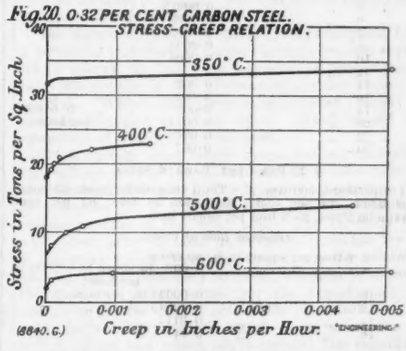
"RECTIFICATION" OF AIR.—The rectification method applied to spirits has for some time been employed to separate all the various constituents of air. According to a paper by Mr. L. D. Goldsmith, published in *World Power*, these constituents distil over from liquid at the following temperatures: oxygen at 90 deg. absolute, argon 87 deg. absolute, nitrogen 77 deg. absolute, neon 27 deg. absolute, helium 4 deg. absolute, krypton 121 deg. absolute, and xenon 164 deg. absolute. The air is in fact the only source from which these rare gases, except helium, can be obtained on a commercial scale.

THE EFFECT OF LOW AND HIGH TEMPERATURES ON MATERIALS.*

By PROFESSOR F. C. LEA, D.Sc.

(*Concluded from page* 817.)

Creep and Rate of Creep.—The results obtained indicated the serious difficulty of finding the real ultimate breaking stress of a piece of metal. Returning for the moment to Fig. 16 it will be seen that at certain stresses the creep gradually became zero, while at other stresses it did not become zero. In curves drawn from tests of steel containing 0·32 per cent. of carbon, and in which the vertical ordinates are elongations and abscissæ time, it was noticed that at certain stresses the elongation time curves at constant stress became parallel to the axis of time; in others, not. The rate of creep which appears for several hours to be constant, can be measured by the slope of these lines, and if from these curves stress-rate of creep curves are plotted, as in Fig. 20, these curves cut, or



become tangent to the axis of stress at some particular stress. This is at least very approximately the stress below which the material will solidify with time, under stress, but above which it continually creeps. The stresses at which the rate of creep curve touches the axis of stress may be called the *t v* stress (f_{tv}) or temperature viscosity stress.

Some particulars of the order of creep are given in

* Paper, abridged, read before the Institution of Mechanical Engineers on Friday, December 5, 1924.

Table VI. Values given in the Table are in certain cases only averages, but are generally the final rate of creep which the material settles down to after a certain time. In Table VII are summarised certain results for four classes of steels.

TABLE VI.—*Stress* = $\frac{\text{Maximum Load}}{\text{Original Area}}$

NICKEL-CHROMIUM-MANGANESE ALLOY.

1st Specimen.

Temperature, 600 deg. C. Total time under load, 170 hours. Maximum load, 22 tons per square inch. Reduction of area 16·5 per cent. Elongation, 15 per cent.

Observed Rate of Creep.

At 12 tons per square inch 0·00018 inch per hour.
" 14 " " 0·0009 " "
" 16 " " 0·0009 " "
" 18 " " 0·0015 " "
" 20 " " 0·006 " "
" 22 " " 0·070 " " Fractured.

At 14 tons per square inch the time that would be required to elongate the specimen 10 per cent. would be over 1,100 hours.

2nd Specimen.

Temperature, 600 deg. C. Total time under load, 150 hours; time at 20 tons per square inch, 13 hours; at 22 tons per square inch, 45 minutes. Maximum load, 22 tons per square inch. Elongation, 15 per cent. Maximum stress, 22 tons per square inch.

Observed Rate of Creep.

At 14 tons per square inch 0·0000342 in. per hour.
" 18 " " 0·0015 " "
" 20 " " 0·006 " "
" 22 " " 0·06 " " Increasing to 0·182 in. and then fracture.

3rd Specimen.

Temperature, 500 deg. C. Total time under load, about 250 hours. Maximum load, 34 tons per square inch.

Observed Rate of Creep.

At 5 tons per square inch, nil.
" 9 " " "
" 10 " " "
" 11–14 " " "
" 14 " " for 18 hours nil.
" 16 " " " 3¾ " "
" 18 " " " 5 " 0·0001 in. per hour.
" 19 " " " 18 " 0·00013 " "
Shut down for 2 days.

Observed Rate of Creep.

For 20 tons per square inch for 23½ hours 0·00015 in. per hour.
" 22 " " " 16½ " 0·000178 " "
" 24 " " " 4½ " 0·00024 " "
" 26 " " " 18½ " 0·000255 " "
" 28 " " " 5½ " 0·0006 " "
" 30 " " " 17 " 0·000604 " "
" 32 " " " 7¼ " 0·00163 " "
" 34 " " " 19 " 0·000726 " "
Furnace left on during week-end, specimen was found broken on arriving Monday morning.

0·14 PER CENT. CARBON STEEL.

1st Specimen.

Temperature, 500 deg. C. Total time under load, 49 hours. Elongation, 20 per cent. Reduction in area, 64 per cent. Maximum stress, 25·3 tons per square inch.

Observed Rate of Creep.

At 2 tons per square inch, nil.
" 4 " " 0·0003 in. per hour to nil.
" 6 " " 0·00025 " "
" 7 " " 0·00025 " "
" 8 " " 0·00054 " "
" 10 " " 0·00040 " "
" 12 " " 0·0260 " "
" 14 " " 0·2400 " "

2nd Specimen.

Temperature, 400 deg. C. Total time under load, 98 hours. Elongation, 22 per cent. Reduction in area, 65·5 per cent. Maximum stress, 31·2 tons per square inch.

Observed Rate of Creep.

At 4 tons per square inch 0·00009 in. per hour to nil.
" 5 " " 0·00015 " " "
" 6 " " 0·0002 " " "
" 7 " " 0·0002 " " "
" 8 " " 0·0003 " " "
" 10 " " 0·0004 " " "
" 12 " " " " "
" 14 " " 0·002 " " "
" 16 " " 0·003 " " "
" 18 " " 0·003 " " to 0·0002.
" 20 " " 0·0013 " " per hour.
" 22 " " 0·006 " "
" 24 " " 0·007 " "

0·32 PER CENT. CARBON STEEL.

Temperature, 500 deg. C. Total time under load, 52 hours. Elongation, 20 per cent. Reduction in area, 64 per cent. Maximum stress, 25·3 tons per square inch.

Observed Rate of Creep.

At 2–6 tons per square inch, no creep.
" 8 " " 0·002 in. down to 0·0002 in. per hour.
" 10 " " 0·0003 in. per hour.
" 12 " " 0·00045 " "
" 14 " " 0·011 " "
" 16 " " 0·04 " "

Significance of these Results.—The importance of these results in connection with vessels under pressure at high temperatures will be apparent. A mild steel at 400 deg. C. will be perfectly safe up to 14 tons per square inch, but if the temperature is maintained at 500 deg. C. the failing stress with time is less than 4 tons per square inch. At 6 tons per square inch it would take very many days before the creep was sufficient to cause serious trouble. The importance of preventing the temperature rising 25 per cent. is much greater than the stress rising by the same percentage.

TABLE VII.—*Showing the Stress, at Various Temperatures, Above which Creep is Continuous.*

Temperature.	Stress.	Remarks.
0·14 per cent. Carbon Steel.		
deg. C.	Tons per sq. in.	
230	33	—
350	28	No creep during 40 hours at 27 tons per sq. in.
400	14	—
500	4	—
600	1	—
0·32 per cent. Carbon Steel.		
350	34	—
400	18	—
500	6	—
600	2	—
0·45 per cent. Carbon Steel.		
400	25 to 30	—
500	9	—
600	3	—
700	1	—
0·75 per cent. Carbon Steel.		
400	30	—
500	16	—
600	6	—
700	2	—
Special alloy steels containing 25 per cent. nickel and a fairly large percentage of chromium.		
500	18 to 20	—
600	16	—
700	9 to 11	—
800	6	—

Plotting the Results obtained from Plottings of Tension Tests.—A parabola of the form $\frac{E}{E_0} = 1 - \left(\frac{\theta}{T}\right)^2$, in which it is suggested by Sutherland that T should be the melting temperature of the metal, θ the temperature of the test, and E_0 the modulus at absolute zero, can be made to fit the experiments with a fair degree of accuracy. Our experiments indicate that the temperature T lies somewhere between 1,200 deg. C. ann 1,600 deg. C. The value of E_0 varies between 13,500 and 14,000 tons per square inch for these steels, but it may be lower for steels cold worked and heat treated in certain ways. The serious difficulty about obtaining a correct law for the variation of the modulus E, partly arises from the fact that steel is a variable material, according to the temperature at which it is tested.

The elastic properties depend also upon the method of arriving at any given temperature. In the limit, at zero stress, the value of the modulus of elasticity may become zero only when the material becomes fluid or is melted. The experiments on creep and viscosity distinctly indicate that at each temperature there is some limiting stress at which there is "solidity," and T is the temperature at which "solidity" in this sense entirely breaks down.

The Effect of Repetition Stress on Materials at High Temperatures.—If the material is subjected to rapid fluctuations of stress first in tension and then in compression, mild steel and alloy steels are capable of resisting very high ranges of stress for very many millions of repetitions without fracture. For example, a specimen of 0·06 carbon steel at 400 deg. C. indicated a distinct limit of proportionality at not more than 6 tons per square inch. At 16 tons per square inch a very large amount of permanent set was produced in the material. At 390 deg. C., however, a specimen subjected to repetition stress withstood over 14 million repetitions at a range of stress of 31·2 tons (± 15·6), and afterwards stood many more millions of repetitions for a range of stress equal to 36·5 tons per square inch without fracture, and even at a temperature of 530 deg. C. the specimen withstood many millions of repetitions with a range of stress of 15 tons per square inch. A number of results are given in Table VIII.

As other interesting examples, the results obtained from specimens of 0·32 carbon steel at a temperature of 479 deg. C., subject to repetition stress in one direction with a mean stress of 15 tons per square inch and a range of stress of 23·0 tons per square inch may be considered. One specimen ran 694,000 repetitions with an elongation only of 14 thousandths of an inch before fracture. An alloy steel specimen of the composition—

C.	Si.	Mn.	S.	P.	Ni.	Cr.
0·3	0·17	0·4	0·02	0·02	3·6	0·6 per cent.

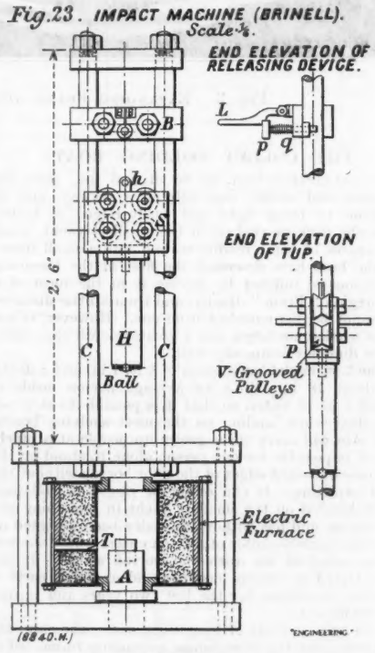
ran 12,392,000 reversals before fracture with an elongation of 8 thousandths of an inch and a range of stress of 40 tons per square inch, 10 tons compression, and 30 tons tension at a temperature of 480 deg. C. The tests, when the stress is always in one direction, are of the greatest interest. If the stress is above a certain range, the specimen creeps in the machine and continuously elongates, but if the range of stress is below a certain amount the creep does not increase indefinitely.

In the case of the repetition stresses, they are being made at the rate of 2,000 cycles per minute, and there is therefore no time, especially when the stress is reversed, for the creep phenomena to operate in any marked degree.

TABLE VIII.—K 4 *Steel.*

Specimen No.	Temp.	Half Stress Range.	Reversals.	Remarks.
	° C.	Tons per sq. in.		
1	510·9	±22·01	106,000	Stopped 21 hrs.
	—	±22·49	2,902,000	Broke.
2	625	±21·28	36,000	Broke.
3	506	±19·95	2,536,000	Stopped 2 mins.
	—	—	4,054,000	Broke.
			6,590,000	Total.
	—	±20·46	1,668,000	Broke.
4	728·2	±20·1	108,000	Broke.
5	724·6	±17·76	1,241,000	Broke.
6	727·1	±18·3	3,675,000	Broke. Stopped several times for 2 mins.
7	729·5	±22·85	38,000	Broke.
8	294	±23·29	20,000	Broke.
9	290·2	±19·96	2,840,000	Stopped 2 hrs. 10 mins.
	—	—	5,742,000	Broke.
			9,602,000	Total.
10	301·1	±20·63	692,000	Broke.
11	291·6	±20·39	1,145,000	Stopped 12 mins.
	—	—	1,827,000	Broke.
			2,972,000	Total.
12	542	±20·01	1,790,000	Broke.
13	537·5	±19·2	2,302,000	Broke.
14	538·6	±19·76	1,761,000	Stopped 2 hrs. 42 mins.
	—	—	1,376,000	Broke.
			3,137,000	Total.
15	761	±19·05	22,000	Broke.
16	136·5	±20·95	518,000	Stopped 10 mins.
	—	—	928,000	Broke.
			1,446,000	Total.
17	768	±17·6	1,112,000	Broke.
18	775·2	±18·22	425,000	Broke.
19	771·5	±17·02	1,397,000	Broke. Stopped 2 mins. several times.
20	869·3	±13·6	708,000	Broke. Stopped 2 mins. a number of times.

Fig. 23. IMPACT MACHINE (BRINELL). Scale ⅛.



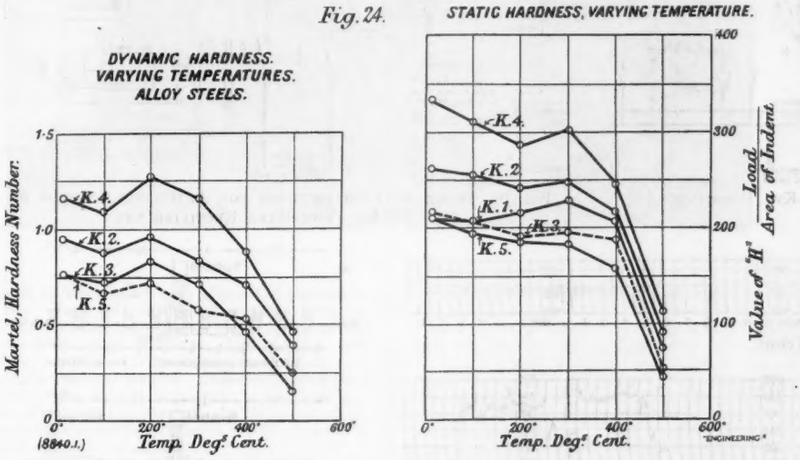
Hardness of Metals at High Temperatures.—The methods used in the author's experiments consisted of (1) Static tests with a Brinell ball at 10 mm. diameter. (2) A dynamic test by means of the apparatus illustrated in Fig. 23, in which a Brinell ball is connected to the hammer H. This hammer is connected to a slider S which moves between the two vertical columns C. In order to diminish friction to a minimum V-groove pulleys, P, are centred on the slider S. B can be fixed in any suitable position along the column C. A small plunger p is pressed out from B under the spring q. The small end of the plunger enters the hole h on the slider S. On tapping the lever L, the slider S is immediately released.

The specimen consists of a small cylinder located by the anvil A at the bottom of the furnace shown in the figure. This anvil can be insulated if needs be by a hard insulating material from the base of the apparatus. The furnace consists of a steel tube T wound with

ni-chrome wire insulated with slag wool. A small tube is inserted through the insulating material, so that a thermo-couple can be introduced to touch the specimen. The specimen being brought to any temperature, the slider is allowed to drop from any suitable height, and, after the blow, is immediately withdrawn. The height of rebound can be observed. A special pair of tongs is used to draw out the specimen, or in the case of steel specimens a magnet can be used. The diameter of the indentation has been measured in the ordinary way.

Static Tests.—A series of static tests on various metals were carried out with loads varying from 200 to 3,000 kg. Plotting area of indentation against load in kilograms, nickel-chrome steel, 0·65 carbon steel, and duralumin, for example, gave straight lines; the curve for delta metal consisted of two straight lines; the inclination of the lines to the axis of load for steel specimens was very much smaller than those for duralumin. Plotting load against the Brinell No. "H" the points lay about curves, which were very nearly straight for loads above 1,500 kg. Static hardnesses were now taken at varying temperatures. These are shown in Fig. 24.

Fig. 24.



Dynamic Tests.—Dynamic tests were made for various heights of fall, or in other words, for varying energy of blow using an impact blow. Martel has suggested that the hardness number is the work required to produce unit volume of indentation. This gives a different hardness number from that produced by the method of Brinell. In order to determine some relationship between the impact instrument and the static method of Brinell, a series of tests were performed at normal temperatures on various materials including carbon and nickel-chrome steels, "Armco" iron phosphor-bronze, gun-metal, brass, delta metal, duralumin. Brinell numbers were first obtained in a Johnson standard machine. In the impact machine for these tests a blow of 0·716 kg. was used. The results are shown in Table IX. Comparative results at other blows have been determined. Plotting the log. Brinell number against log. of diameter, the points lie approximately about a straight line having the equation $H = 5{,}706\ d - 2{\cdot}93$. Plotting the diameter of the impact against the Brinell diameter, the points lie approximately about a straight line. Varying the energy of impact and plotting energy of blow against diameter of indentation, a series of curves were obtained of the form

$$d = CE^n,$$

d = diameter of impact,
E = energy of impact.

For the duralumin C = 4·88 and n = 0·286,
,, the delta metal C = 4·25 and n = 0·343,
,, ·K2 steel. C = 3·42 and n = 0·376.

The hardness numbers as obtained from the energy of the blow are plotted in Fig. 24. It will be seen that the curves are similar in form to the Brinell number curves of the same Fig.; but the maximum hardness occurs at a lower temperature and at a lower temperature than the maximum tensile strength.

This very brief account of the hardness results has been added to show that up to a temperature of 500 deg. C., the hardness curves, whether obtained statically or dynamically, give indications of the tensile strengths as obtained in the ordinary way, but they do not give indications of the temperature-viscosity stresses, neither do they give any indication of the form of the curve for repetition ranges of equal plus and minus values.

Summary.—The results obtained show that for each of the steels tested there is at each temperature a stress which, if exceeded, will cause continuous creep. For vessels or elements of machines that are subjected to stress in one direction, this "creep" stress is the stress with which the working stress should be compared to obtain the factor of safety.* For a steel containing 0·14 per cent. carbon, the creep stress is slightly higher than at ordinary temperatures. As long as the temperature of working is below 300 deg. C. the factor of safety is not very different from the usual value, obtained by dividing the breaking strength of the steel by the working stress. At a temperature of 400 deg. C., for a working stress of 6 tons per square inch, the ratio of "creep" stress to working stress is only 2·33. A vessel would withstand a pressure producing a stress of 14 tons per square inch for a very long time without fracture. At a temperature of 500 deg. C. the "creep" stress is reduced to 4 tons per square inch, and thus the factor of safety, if sufficient time is allowed and the working stress is maintained at 6 tons per square inch, has become less than unity. An increase of 25 per cent. in the working stress at 400 deg. C. (673 deg. C. abs.) will only diminish the factor of safety from 2·33 to 1·93 whereas an increase in the temperature of 15 per cent., reckoned on a basis of absolute temperature, while keeping the pressure constant, diminishes the factor of safety from 2·33 to less than unity.

TABLE IX.—*Comparison of Static and Dynamic Hardness.*

Energy of Blow = 0·716 kgm.-metre.
Static Load = 3,000 kg.

Metal.	Brinell No. H.	Log. H.	d = Diam. of Dynamic Indentation. Log. d.
Brass	126	2·1	0·563
Muntz Metal	107	2·029	0·602
Delta	107	2·029	0·602
Gun-metal	95	1·978	0·624
Phos. Bronze	116	2·064	0·591
J4	112	2·049	0·580
"Armco" Iron ..	99	1·996	0·591
K1	207	2·316	0·477
K2	255	2·407	0·470
K3	217	2·336	0·491
K4	—	—	—
K5	212	2·326	0·491
Dural. A	217	2·336	0·462
,, B	217	2·336	0·477
,, C	179	2·253	0·519
Mild Steel	179	2·253	0·505

The control of temperature, when materials are subjected to temperatures of more than, say, 350 deg. C. is thus more important than the control of pressure. For high-pressure boilers and superheaters, of mild steel, the factor of safety for temperatures of 800 deg. F. (427 deg. C.), for a continuously applied stress of 6 tons per square inch is only about two, but this is clearly ample provided the temperature is not exceeded.

The effect of temperatures below normal temperatures down to — 80 deg. C., is clearly not important as far as tensile strength is concerned. Tests are required, however, on the effect of low temperatures on impact values.

The results of the tests on materials at high temperatures, subject to repetition stresses, show that very many millions of rapidly repeated stresses of magnitudes far greater than the creep stress can be applied without risk of fracture. These results throw important light on the possibility of materials heating after slipping, and indicate that viscosity plays an important part in the behaviour of materials subject to rapid repetitions of stress at high temperatures. If the fluctuations of stress are small and the stress is always in one direction the conditions approximate more and more to the statical condition, and further, if the time of application in one direction is not very small the time factor becomes of great importance and failure may occur.

* The term is used in the usual way as the ratio of the direct stress to the direct working stress.

AUTOMATIC AND SEMI-AUTOMATIC MERCURY VAPOUR RECTIFIER SUB-STATIONS.*

By G. ROGERS, A.M.I.E.E.

(*Concluded from page* 784.)

Automatic Booster Rectifier Substation for Feeding into Existing D.C. Networks.—Many supply undertakings are now finding their existing direct-current feeders from the generating stations and rotary substations overloaded on the peak. Many of these feeders have been run out to considerable distances, with the result that when loaded up there is a big drop in voltage, necessitating the use of special boosters. The use of boosters is very inefficient, and to deal satisfactorily with large currents and big voltage-drops involves boosters which are very expensive pieces of apparatus. To deal with the load, it becomes necessary either to lay new feeders or to build and equip new substations. One method of solving this problem was described in a paper† read before the Institution by Mr. P. J. Robinson, of Liverpool. This method was to instal automatic rotary converter substations feeding direct into the net work at points of low pressure, and so to relieve overloaded feeders.

It was necessary to relieve the load on four existing low-tension feeders in the Central City district, and an examination of the estimated cost of three possible methods of dealing with the problem of overloaded feeders and bad pressures showed a considerable saving in favour of the mercury-vapour rectifier equipment. It was decided to erect four small substations, each equipped with mercury-vapour rectifiers, having a capacity of 276 kw. (that is, 600 amperes at 460 volts), feeding across the outers only, at a point in the network suitable for relieving the overloaded feeders and for improving the voltage. Each unit is made up of four 150-ampere bulbs (two per transformer) connected in parallel. In each case the overloaded feeder was 1 sq. in. in cross-section, and the rectifier substation was therefore capable of taking up approximately half-load on the peak. The plant in each of these substations is designed to be entirely automatic in its operation.

Fig. 8 shows the main connections and the protective gear provided for each 276 kw. unit. The e.h.t. supply to each transformer is controlled by means of a hand-operated oil switch provided with overload coils in each phase. These switches are normally left closed. The supply to the pair of transformers is controlled by an electrically-operated oil switch, also provided with overload protection. The direct-current circuit breaker is provided with overload protection and recloses after a definite time interval when the overload condition is removed.

The method of starting up and shutting down the set as required is comparatively simple, and follows the practice adopted for automatic rotary converters. It is, however, much simpler and requires a much smaller number of relays. The diagram of connections is shown in Fig. 9.

The figure shows (1) A master relay energised from a potential transformer across the high-tension supply which allows the following sequence of operations to take place only if the alternating-current supply is normal. When the alternating-current supply is normal, contacts (1*a*) are open. When closed the operation of relay (2) is prevented.

(2) A voltage relay which opens contact (2*a*) when the voltage across the direct-current feeder falls to a predetermined value. The opening of contact (2*a*) de-energises (3) a time-delay by inserting the high resistance (3*a*) in the relay coil. The contacts (3*b*) now close after a time interval (adjustable up to 5 minutes) which energises (4) a contactor solenoid, causing the contact (4*a*) to close, which in turn closes the main oil switch supplying the transformer by energising (5) the closing coil of the oil switch.

(6) An auxiliary switch which closes when the oil switch closes and which short-circuits the resistance (3*a*), again energising the time-delay (3). The contacts (3*b*) open and the contactor (4) is de-energised, opening the closing coil circuit. The transformer or transformers supplying the rectifier bulbs are now charged and the bulbs will tilt and strike the arc by the operation of the starting relays.

As soon as the excitation arc has been struck in all bulbs, the contacts (7) close. These contacts (one

* Abstract of paper read before the Institution of Electrical Engineers in London, on November 20.
† Journal I.E.E., 1923, vol. lxi, page 417.

for each bulb) are in series, and can be short-circuited by means of a switch in order that one or more bulbs can be cut out if not required.

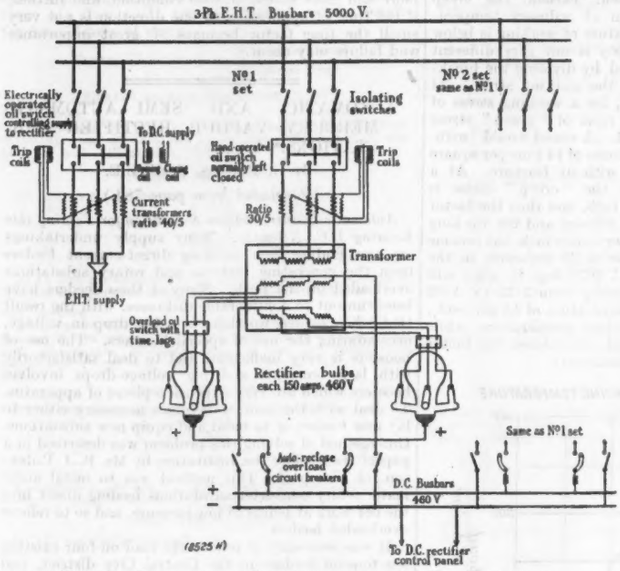

3-Ph. E.H.T. Busbars 5000 V.
No 1 set
No 2 set same as No 1
Isolating switches
Electrically operated oil switch controlling supply to rectifier
To D.C. supply
Trip coils
Hand-operated oil switch normally left closed
Current transformers ratio 40/5
Ratio 30/5
Transformer
E.H.T. supply
Overload oil switch with time-lags
Rectifier bulbs each 150 amps. 460 V
Same as No 1 set
Auto-reclose overload circuit breakers
D.C. Busbars 460 V
To D.C. rectifier control panel
(8525 H)

FIG. 8. DIAGRAM OF CONNECTIONS OF 276-KW. BOOSTING RECTIFIER SUB-STATION.

self-contained. Its function is to parallel the rectifier bulbs to the direct-current feeder supply. It is in the positive pole, the negative pole of the rectifier being connected to the feeder negative through a knife switch and fuse. Its operation is as follows :—

The controlling coil (9), when energised, closes contacts (9*a*). This short circuits the resistance (9*b*) and in turn energises the operating coil (10) which closes the circuit breaker (11). The closing of the circuit breaker opens contacts (10*a*) and (10*b*), which de-energise the controlling coil (9) and the relay (8) respectively.

The operating coil of the breaker is also interlocked through contacts (6*a*) with the high-tension oil switch.

The voltage relay now comes into operation and adjusts the rectifier voltage to the particular setting of the relay. (The connections of the voltage regulator are shown in Fig. 7.)

A further relay (12), a maximum-current relay, comes into operation when the full load is exceeded, and operates to lower the voltage.

The direct-current circuit breaker is set to operate on overload, reclosing after a definite time interval provided that the excessive overload conditions are removed.

When shutting down and when the load falls to a predetermined value, relay (13), a minimum-current relay operated from a shunt in the feeder circuit, opens its contacts (13*a*) and de-energises (14) a time-delay relay by inserting resistance (14*a*) in the coil circuit.

After a definite time interval, contacts (14*b*) close and energise (15) the trip coil, which causes the main high-tension oil switch to open.

The auxiliary switch (6*a*) opens when the oil switch opens and causes the direct-current circuit breaker to open.

Also the opening of the direct-current circuit breaker closes the auxiliary contacts (11*a*), resetting the time-delay relay (14) by short-circuiting the resistance (14*a*).

The rectifier is now disconnected from the high-tension busbars, and the direct-current positive circuit breaker is disconnected from the direct-current feeder, and the set will start up again when the direct-current voltage of the feeder falls low enough to operate the low-voltage relay (2), subject to the alternating-current pressure being normal.

A typical load and voltage curve over a period of two days is shown in Fig. 10.

Semi-Automatic Traction Sub-Stations.—An extension to the Selly Oak Overhead tramway route from Selly Oak to Rednal and Rubery, a distance of approximately 5 miles (see Fig. 2), had to be supplied with current at 550 volts. The Selly Oak end of the existing route was about 2½ miles from the nearest manually-operated rotary sub-station, and it was from this sub-station that the existing route received its supply.

Very heavy traffic was to be expected on this route at holiday times and at week-ends during the summer, and it was necessary to provide plant and feeder cables capable of dealing with a half-minute service of cars. In addition to this holiday load, however, which would occur on only a comparatively few days in the year, there was a certain amount of rush traffic at certain times of the day. It will be clear, therefore, that for the greater part of the day and year a big proportion of the plant necessary to deal with the rush traffic would be idle.

It was obviously impracticable to supply the new route by means of new feeders run out from the existing sub-station, owing to the high cost involved. To build and equip a new manually-operated rotary sub-station somewhere on the new route would also have been prohibitive in capital and running costs. It was clearly a problem which admitted of only one solution, namely, automatic or semi-automatic plant which would require the minimum of labour and running charges.

After much consideration and comparison of the costs of various types of plant, it was decided to put down ultimately three sub-stations, one at Selly Oak, one at Northfield, and one at Longbridge. Each of these sub-stations has plant installed of a total capacity of 660 kw., making a total of 1,980 kw. for the three sub-stations.

Fig. 11 (*a*) shows the feeding arrangements when the Northfield sub-station was put in service. Fig. 11 (*b*) shows the second position when the Selly Oak sub-station was put into service, and Fig. 11 (*c*) shows the complete scheme with the three sub-stations and the feeder arrangements from each sub-station. It will be seen that the negative return feeder is connected to the rails immediately outside the sub-station in each case. This arrangement enabled the cost of the direct-current traction feeder system and also the rail voltage drops to be kept to a minimum, without undue expenditure on negative feeders.

The plant decided upon was the mercury-arc rectifier of the glass-bulb type. Each sub-station is equipped

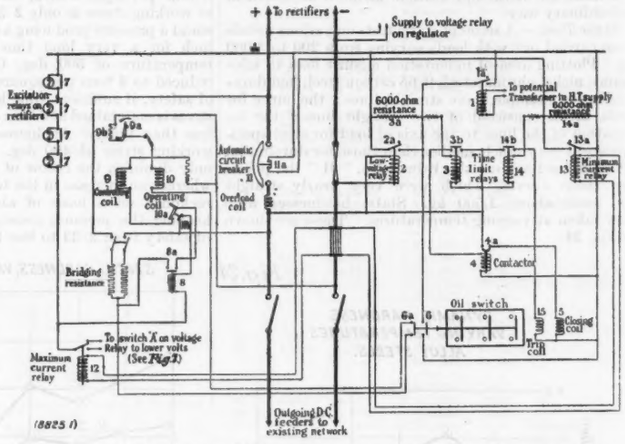
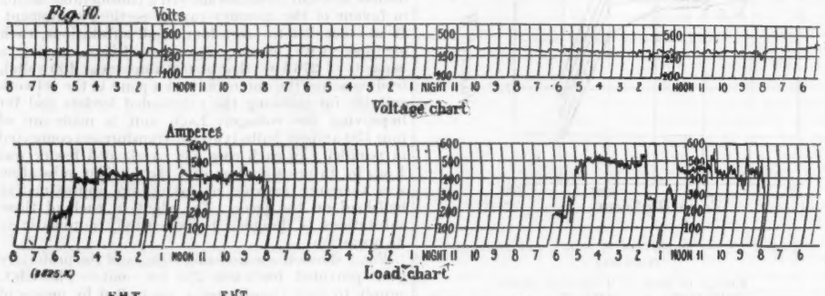


FIG. 9. DIAGRAM OF CONNECTIONS FOR AUTOMATIC CONTROL OF ONE 276-KW. TWO-WIRE RECTIFIER SET.



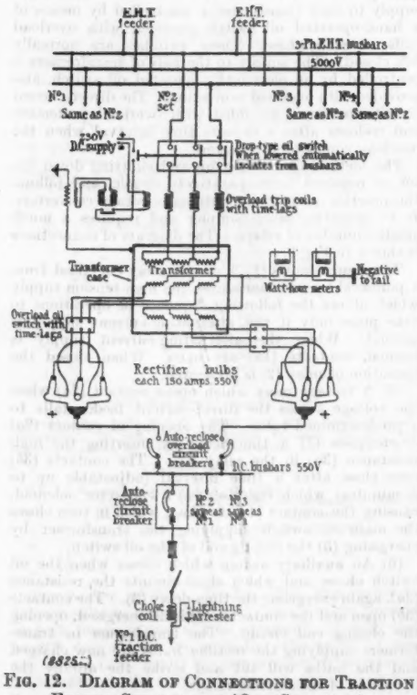

E.H.T. feeder
3-Ph. E.H.T. busbars 5000 V
No 1 Same as No 2
No 2 set
No 3 Same as No 2
No 4 Same as No 2
230 V D.C. supply
Drop-type oil switch When lowered automatically isolates from busbars
Overload trip coils with time-lags
Transformer case
Transformer
Watt-hour meters
Negative to rail
Overload oil switch with time-lags
Rectifier bulbs each 150 amps. 550 V
Auto-reclose overload circuit breakers
D.C. busbars 550 V
Auto-reclose circuit breaker
No 2 same as No 1
No 3 same as No 1
Choke coil
Lightning arrester
No 1 D.C. traction feeder
(8825 J)

FIG. 12. DIAGRAM OF CONNECTIONS FOR TRACTION FEEDER SUB-STATION (ONE SET ONLY).

(8) A solenoid relay is now energised and the contacts (8*a*) close, which in turn energise (9) the controlling coil of the auto-reclose circuit breaker. This circuit breaker is an Igranic reclose circuit breaker which is

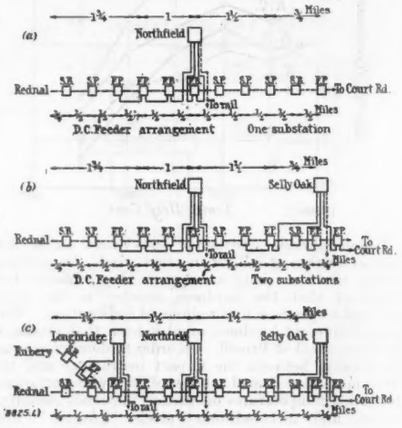


FIG. 11. D.C. Feeder Arrangement. Final. Three Sub-stations.

150-H.P. FOUR-CYLINDER VERTICAL GAS ENGINE.

MESSRS. BROWETT, LINDLEY AND CO., LIMITED, MANCHESTER.

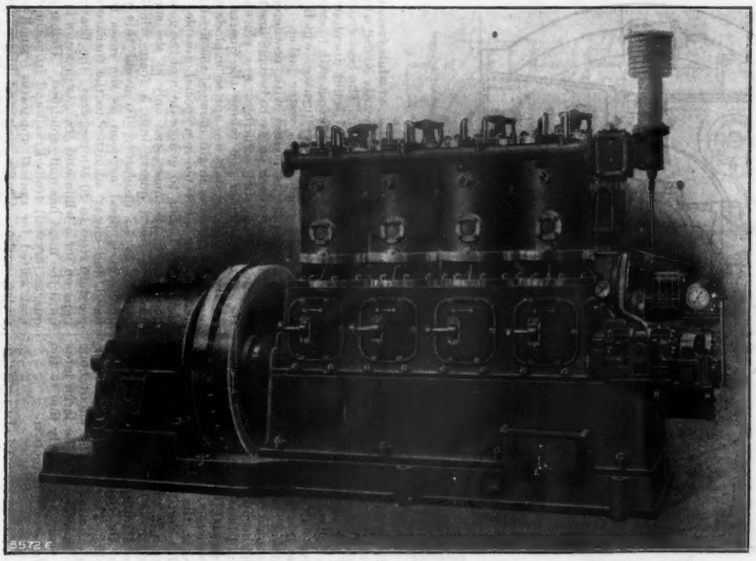


FIG. 1.

with eight rectifier bulbs, each giving 150 amperes at 550 volts. Each pair of these is supplied from one transformer, making use of the six phases of star-wound three-phase secondary windings. The complete unit of 660 kw. capacity consists of four transformers, each supplying two bulbs in parallel. This arrangement gives great flexibility, since it is possible to run with any number of the bulbs in parallel. In the event of one transformer breaking down there is till 75 per cent. of the plant available for service.

The high-tension supply to the sub-stations is 25-period, three-phase, at 5,000 volts. The high-tension switchgear used is the same type as that used in the three-wire lighting stations. All the rectifiers feed into a common positive busbar through Igranic reclose circuit breakers. The positive busbar is connected to the control panel for the low-tension traction feeders by means of cable. Each low-tension traction feeder is controlled by means of an Igranic reclose circuit breaker through a disconnecting switch of the knife pattern and a choking coil. This arrangement of control is shown in Fig. 12.

The control of this sub-station is only semi-automatic, it being the practice to leave the necessary number of sets running to supply the ordinary load and to switch in additional sets when required for extra load. The transformers are protected by means of series overload coils in the high-tension switchgear. Further protection for the transformers is obtained by means of a leakage relay placed in the earth circuit of the transformer. A small leakage of 2–3 amperes to earth from the transformer windings is sufficient to open the main oil switch.

The series overload coils are fitted with a time lag, which is so adjusted that in the event of any trouble on the direct-current side of the plant the low-tension switches would have a chance of operating first.

The low-tension secondary connections from the transformers to the rectifiers pass through special three-phase oil circuit breakers, also fitted with a time lag. The direct-current Igranic circuit breaker in each rectifier gives further automatic protection in that it is designed to operate on overload and will reclose when the overload condition has been removed.

The main automatic features, however, are on the outgoing feeders themselves. The circuit breakers controlling these feeders are arranged to open instantly on a predetermined overload and will reclose after a definite time interval, providing that the overload conditions have been removed. These switches act perfectly and operate on overload or external short circuit before any of the other protecting gear in circuit with the supply can operate. In the event of an overhead wire breaking down, the circuit breaker controlling the supply to that particular section will open and will not close again until the "earth" has been removed. Instantly the wire has been removed from the ground, the circuit breaker closes and the overhead wire is again made alive. Special instructions in this connection have been issued to the Tramway Department for the protection of their men.

In the event of a failure of the high-tension supply pressure, no switches will operate in the sub-station except the low-tension feeder and rectifier control switches if the station is isolated from any other supply, and when the high-tension supply is restored the sets will automatically be started up and the supply restored to the direct-current feeders. This arrangement has up to the present worked perfectly satisfactorily, and every part has functioned correctly.

The power factor and efficiency of the traction rectifiers are shown in Fig. 5 (*c*). It will be seen that the efficiencies obtained are comparable with the efficiencies of rotary converters.

Sites and Buildings.—It is not a very difficult matter to obtain a suitable site for a comparatively small building on the outskirts of a city. Land belonging to the public authorities should first be exploited for possible sites; quite a fair percentage of the sub-stations in Birmingham are erected on Corporation property belonging to other departments. Some are erected in the school playgrounds, and others in the grounds belonging to the Water Department. Failing a suitable site to be mutually arranged with other departments in this manner it is possible, owing to the absence of noise from plant of this type, to buy or lease a small site, particularly when an area is being developed for building purposes.

In the city itself, however, a suitable site is often very difficult to obtain, and it may be necessary to adapt an old building or to build on an irregular-shaped site for the purpose of housing the rectifier plant. Some ingenuity and patience has to be exercised in this respect. The principal requirements of a site are suitability of access for plant and cable ways.

In designing buildings for this particular class of work, it must be borne in mind that simplicity, cheapness and freedom from fire risks must be the principal factors. There will be no attendants in these stations, and it is not necessary to have any idle floor space in the building. The plant does not require any lifting tackle, the transformers being mounted on wheels.

In most cases the question of appearance of the building and its relation to surrounding property in residential areas has to be considered. Many of the substations described in the paper had to be specially designed from an architectural standpoint to suit the wishes of the owners of surrounding property, and of course, in every case to satisfy the city surveyor. Further, the bye-laws relating to buildings have to be observed, and it is therefore wise to put the design of new buildings of this kind in the hands of a good architect who will arrange to satisfy the many interested parties.

The peculiar light from the bulbs, and the flicker due to the rotating arc, make it advisable to prevent any direct light from the substation being seen outside. One way of doing this is to provide V-shaped louvres in the walls of the substation.

A suitable cable trench to bring in the necessary cables and suitable drainage from the roof for storm water must be provided.

Usually, a single-floor building is most suitable, but where the ground space available is small, a two-storey building can be readily adapted for this purpose, the transformers being placed on the ground floor, and the rectifiers and switchgear on the first floor.

Conclusion.—The author makes no claim that the type of rectifier substation described in this paper is complete or in final form, but takes the view that in each case an attempt has been made, with some success, to develop and use new plant for special purposes, to the end of reducing costs of development.

Attempts have been made to discriminate in each case the automatic features essential for the successful operation of the gear. It is possible to carry automatic control to almost any extent of completeness, but this only adds to the complexity of the switchgear and also increases the cost.

The author would like to express his indebtedness to Mr. R. A. Chattock, the city electrical engineer, for his kind permission to publish the information contained herein, and to his assistants, Mr. Thurman and Mr. Deeming, for their help in preparing the various diagrams included in the paper.

BROWETT-LINDLEY 150-H.P. FOUR-CYLINDER VERTICAL GAS ENGINE.

As an example of a gas engine working on the four-stroke cycle, which is of the enclosed vertical type and has a well-designed lubrication system, we illustrate on this page and on page 848 a four-cylinder engine made by Messrs. Browett, Lindley and Co., Limited, of Sandon Works, Patricroft, Manchester. This firm has had considerable experience in meeting the requirements of gas engine users, for they have designed and built engines for direct coupling to electric generators since the earliest days of the electrical industry. In Fig. 1 the engine is shown directly coupled to an electrical generator of 100 kw. capacity made by the Lancashire Dynamo and Motor Company, Limited. Though this is a common service to which these engines are put, they are also built for driving centrifugal and plunger pumps and air compressors, and as the source of power for the machines in workshops.

This gas engine was designed to give 150 brake horse-power, and runs at a speed of 428 r.p.m. The cylinders have a diameter of 12 in. with a stroke of 11 in. It is built on a substantial cast-iron bed constructed on the double-girder system, and providing support for the four bearings of the crankshaft. On top of the bed there is bolted a frame, which forms the support for the cylinders, and is provided on both sides with doors of ample size to ensure freedom of access to the working parts. As the base and frame are divided near the crankshaft centre line, it is possible to lift the crankshaft out vertically. This is an advantage where engine-room space is a serious consideration, as it is necessary, when engines are arranged so that the shaft must be taken out horizontally, to provide additional space for the purpose. The cylinders are cast with their water jackets, and are fitted with loose joint rings to relieve any possible strains due to temperature actions. Cleaning holes are available in the walls of the jackets to permit access to every part. When the joints are made in the process of assembly of these engines a water pressure of 100 lb. per square inch is used to test the jackets.

After the pistons of this engine are rough turned they are annealed to relieve all strains, and are then finished to size by grinding. For the connecting rods mild steel forgings are used, and these have the small end of eye-form, with a phosphor bronze bush, and a big end of the marine type, with gun-metal bushes lined with white metal. The crankshaft is of Siemens-Martin forged steel, with the throws cut from a solid block. It is increased in diameter and given a long bearing support near the flywheel and the coupling flange is forged solid with it.

At the side of each cylinder casting, provision is made for the accommodation of the valves. The exhaust valve is made of chilled cast iron, but the inlet one has a steel spindle, which is first screwed into a cast-iron head and then riveted over. The inlet valve is located above the exhaust one and is housed in a removable box and guided by a piston type of collar. When the inlet valve is withdrawn sufficient clearance is available for the removal of the lower valve for inspection or cleaning. For the operation of the valves, motion is taken from case-hardened steel cams on a shaft enclosed within the frame of the engine. By means of hardened rollers, fitted in guides of the piston type,

150-H.P. FOUR-CYLINDER VERTICAL GAS ENGINE.

CONSTRUCTED BY MESSRS. BROWETT, LINDLEY AND CO., LIMITED, ENGINEERS, MANCHESTER.

Fig. 2.

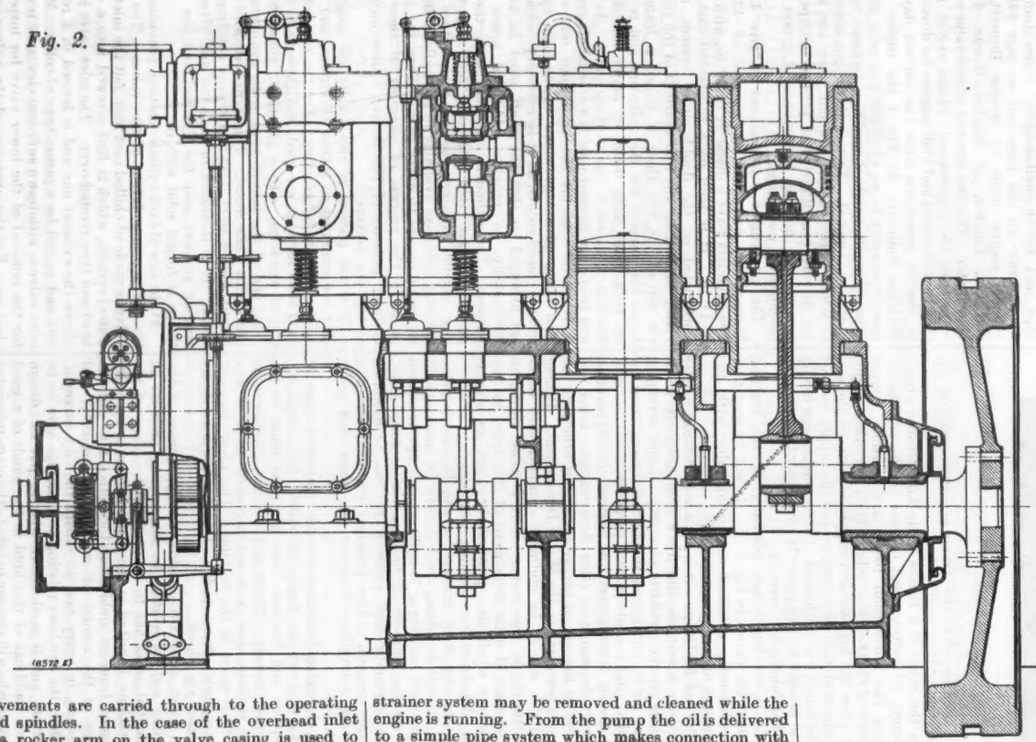
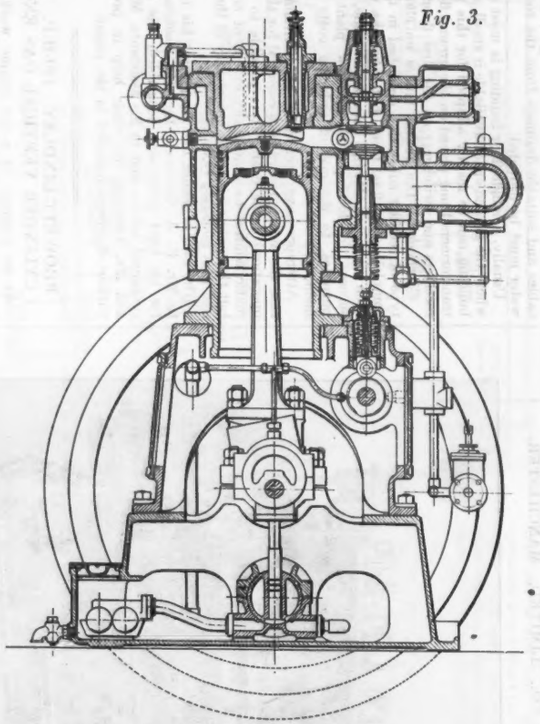


Fig. 3.



the movements are carried through to the operating rods and spindles. In the case of the overhead inlet valves a rocker arm on the valve casing is used to transmit the movement obtained from the vertical operating rod. Adjustment to maintain the required clearances between the valve stems and the rods is easily performed, and as the provision made is outside the frame it is easily accessible. A centrifugal governor is mounted at the end of the crankshaft and operates on the gas admission, the arrangement of the gear for which is shown in Fig. 2. Simple means of adjusting both the governor weights and springs are available, and arrangements are made to permit altering the speed while the engine is running. The standard system of ignition used with these engines is high-tension magneto and an impulse starter is fitted.

As the moving system of this gas engine, including the governor, is enclosed in the frame and base of the engine, it is well protected from the incursions of foreign matter of any kind. The working surfaces of these parts are effectively lubricated by oil obtained from a valveless pump, the construction of which is clearly indicated at the bottom of Fig. 3. The rocking action caused by the movement of the plunger, which is really an extension of an eccentric rod, is used to put the cylinder end in connection with the inlet or the delivery ports in turn. A double strainer in the inlet system serves to keep the oil, which enters the pump, entirely free from grit. Either half of the strainer system may be removed and cleaned while the engine is running. From the pump the oil is delivered to a simple pipe system which makes connection with the bearings, while the crankshaft is drilled to convey lubricant to the big ends and passages through the connecting rods are used to take oil to the gudgeon pins.

All engines of this type are arranged to be started with compressed air. Once the engine is put in the starting position and the compressed-air valve is opened the whole action of starting is purely automatic. Air for the purpose is obtained from a small, independently driven compressor and is stored in a receiver at 250 lb. per square inch. The average of a number of tests shows that a heat consumption of slightly less than 10,000 B.Th.U. is required per horse-power-hour. This is equivalent to about 0·8 lb. of anthracite or 1 lb. of bituminous coal of average quality, allowing for the usual producer efficiencies. It should also be noted that these engines are capable of meeting an overload of 10 per cent. for a period of half an hour or short overload peaks of a much greater magnitude.

THE SOCIETY OF ENGINEERS.—The Council of the Society of Engineers have decided to recommend to Captain W. J. Liberty, the Secretary of the Institute of Public Lighting Engineers, the "Nursey Premium," value 3*l.* 3*s.*, for his paper on "Underground London," read before the society at their autumnal meeting at Burlington House.

RESEARCH WORK ON RUBBER PLANTATIONS.—The question of rubber research done on the plantation, often touched upon at meetings of the Institution of the Rubber Industry, was the subject of a paper read on December 1 before that body by Major B. J. Eaton, F.I.C., who has spent 18 years in Malaya. Research is done in the field and in the laboratory, and Mr. Eaton dealt more with general features than with chemical problems. Research, he said, should be State-supported and organised; Mr. Burgess, who occupied the chair, emphasised also that workers should bear in mind the common interest and not follow up special lines enabling them to present papers to home societies. The problems, of tapping, diseases, insect pests, the soil, &c., Mr. Eaton pointed out, were manifold. Fertilisers for rubber trees had done little good on virgin jungle soil as long as the surface was not eroded by rains. Plantation rubber need not be less uniform than Para rubber, and the age of a tree had little influence on the quality of the rubber, though it affected the yield. The ammonia added to rubber latex to preserve it did affect the caoutchouc slightly, in a way not yet understood. The large latex shipments of the past few years were partly due to the need for finding an outlet for over-production.

ELECTRIC FURNACE FOR FUSING SILICA.—In order to obtain homogeneous and clear silica, free from blemishes and gas bubbles, especially for optical purposes, Hugo Helberger, of Munich, makes use of an electric furnace, in which a vacuum is maintained while fusion takes place, but the fused mass is afterwards cooled while under gas pressure of 20 atmospheres. The best crucible material is silicon carbide; graphite would discolour the quartz, and refractory oxides would react with fused silicon. The crucibles are made in the furnace, which is provided with a sight hole and a water jacket. The original graphite crucible is coated with powdered silica and heated in the furnace so as to become lined with silicon carbide. Two such crucibles are placed one inside the other, the inner one taking the quartz to be fused. As the quartz crystals are apt to explode when heated and the fragments might damage the final crucible, the first heating is effected in a special crucible. Once fused the quartz begins to evaporate and the gases which are liberated in the mass—not only at the surface—transform the fused quartz into a foam which might be utilised as an insulator. To avoid this foaming, the pump is stopped as soon as the mass is thoroughly fused, and gas is admitted to the furnace until the gas pressure rises to 20 atmospheres; the heating current is kept on for a while and the gas pressure is not released until the mass has quite solidified. Helberger has found quartz (crystal) from Brazil and from the St. Gotthard best suited for optical apparatus: small enclosures of water, carbon dioxide, salt and glassy rocks are not uncommon in ordinary crystal, and pure fragments of crystals have to be picked out when high homogeneity of the quartz glass is required.

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The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 1s.

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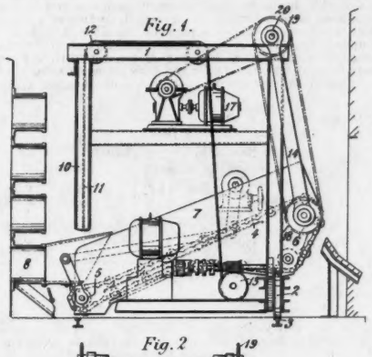
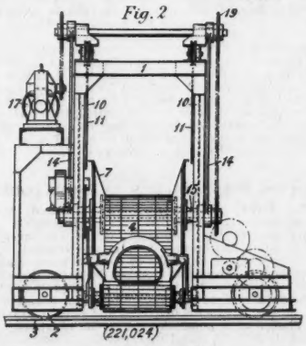
Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

GAS ENGINES, PRODUCERS, HOLDERS, &c.

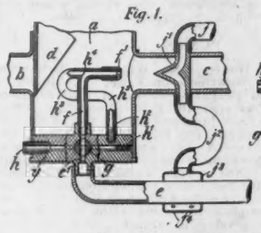
221,024. Ride, & Bell Limited, Misterton, and G. Bell, Retford. Apparatus for Removing Coke from Retorts. (7 *Figs.*) June 15, 1923.—The invention relates to apparatus for removing coke from a battery of super-imposed series of retorts. A frame 1 is mounted on wheels 2 running on rails 3 disposed parallel to the battery of retorts. An endless band conveyor 4 for transporting live coke is carried around drums 5 and 6 mounted in a framework 7. This conveyor framework 7 comprises guide walls at the sides of the upper surface of the conveyor, as seen clearly in Fig. 2. The end of the framework 7, which is adjacent to the retort mouthpieces 8, is guided in a substantially vertical path by means of rollers mounted on the framework and engaging guides 10 provided by vertical members of the frame 1. This end of the framework 7 is supported by a chain 11 passing over pulleys 12 and





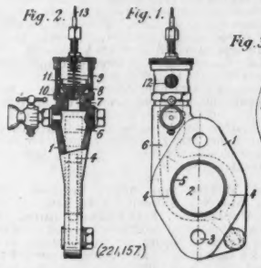
connected to a winding drum 13, whereby this end of the framework may be lifted or lowered to the level of the retort mouthpiece from which it is desired to discharge coke. The other end of the conveyor framework 7 is suspended from the main frame 1 by means of links 14. The links are pivoted to the framework 7 co-axially with the rollers 6 at this end, the roller bearings 15 being extended to provide journals for the links 14. Thus the common axis of the rollers 6 and framework 7 is supported by the links 14, and is defined by the spindle of the rollers 6. The conveyor 4 is driven from a motor 17 carried on the main frame 1, by chain gear, one of the chain wheels 18 of such gear being keyed to the spindle of the rollers 6 carrying the conveyor, and another 19 is mounted co-axially with those pivots 20 of the links 14 which are carried by the main frame. (*Sealed.*)

221,143. J. Thomas, Llanganoyd, near Bridgend, and W. Harding, London. Carburetting Apparatus. (4 *Figs.*) January 24, 1924.—The invention relates to carburetting apparatus and vaporizers for internal combustion engines. According to the invention, the apparatus is provided with a hand-operated tapered cock inserted in the base thereof and provided with two passages controlling, respectively, the admission of liquid fuel and air or gas under pressure, whether hot or cold, to a common nozzle for the purpose of imparting a greater velocity to the fuel jet and also for giving a quicker and a more thorough vaporization of the fuel issuing from the jet. *a* is the carburettor casing; *b* the main air inlet; *c* the connection to the engine on the induction side; and *d* the conventional throttle valve; *e* is the petrol supply pipe, and *e*1 the passage leading therefrom into the jet pipe; *f* is the main petrol jet pipe and *f*1 the jet nozzle which is detachable for purposes of cleansing or jet changing. In carrying out the invention, the base piece *y* of the carburettor is provided with a horizontal conical passage *y*1 in which there is arranged a hand-operated tapered cock *g* provided with two passages adapted to control, respectively, the fuel and the air or gas under pressure, the passage *g*1 being that for the fuel supply and *g*2 that for the supply of the air or gas under pressure. The different relative positions of the fuel supply *g*1 and the air or gas under pressure supply *g*2 are clearly shown in Fig. 2 as is also the vertical orifice *h*2 leading air or gas under pressure from the supply-pipe hereafter referred to. Extending across the base *y*, and at right angles to the conical passage *y*1, is the inlet *h* leading from any external source of air or gas under pressure; the unwanted length of the passage being plugged by a screw *h*1. *h*2 is the vertical orifice from the inlet *h* in the base piece *y*, and into which leads the end of



the air or gas under pressure pipe *h*3, which joins the fuel pipe at *h*4 (see Fig. 1). *j* is the inlet pipe through which the hot gases pass into and through the usual conical diffuser or atomizer-vaporiser *j*1, which diffuser is arranged within the connection to the engine. *j*2 is a subsidiary pipe leading from the diffuser to a jacket *j*3 arranged around the fuel supply pipe *e* for the purpose of warming the pipe, when desired, and *j*4 are perforations in the jacket to allow of the escape of gas. (*Accepted September* 10, 1924.)

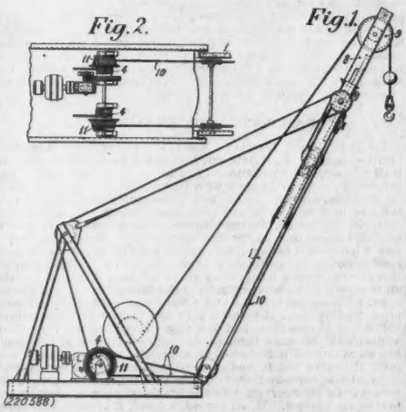
221,157. A. H. Moss, Misterton. Internal-Combustion Engines. (4 *Figs.*) March 3, 1924.—The invention relates to devices for admitting an auxiliary supply of air to the fuel mixture in the induction pipe leading from the carburettor to the cylinder of an internal combustion engine. The device comprises a body 1 having a boring 2 adapted to form part of the induction passage leading from the carburettor to the cylinder of an internal combustion engine. The body 1 comforms in outline to the flanges by which the induction pipe is bolted to the carburettor and is intended to be fitted in place between these parts by mean of bolt holes 3. The body 1 is formed with a recess 4 entirely surrounding the part of the induction passage constituted by the boring 2, the recess 4 thus forming an enlargement of the induction passage from which it is separated by a partition 5 having



jet-producing apertures, as shown more clearly in Fig. 3, for causing a fine sub-division of the air flowing through it. If desired, the partition 5 may be in the form of fine wire gauze or it may be in two parts separated by a sufficiently narrow space to produce a jetlike or spraying action on the air passing from the recess 4 into the part of the induction passage represented by the boring 2. The recess 4 is continued at 6 to an opening 7 to the atmosphere and this opening 7 is controlled by a valve 8, which is preferably spring-controlled as indicated at 9 and is conveniently contained in a casing 10 having air inlets 11 protected by wire gauze 12. The valve 8 is normally closed by its spring 9 and is controlled by hand from the driver's seat by means of a Bowden wire 13. The casing 10 may be integral with the body 1 or, as illustrated, may be a separate fitting screwed to the body. (*Sealed.*)

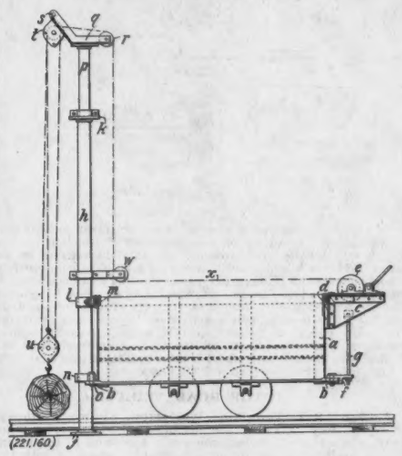
LIFTING AND HAULING APPLIANCES.

220,588. Thomas Smith and Sons (Rodley), Limited, Rodley, Leeds, and E. Fawcitt, Rodley, Leeds. Jib Cranes. (3 *Figs.*) April 15, 1924.—The invention relates to jib cranes fitted with separate drums, *i.e.*, one for hoisting the load and



one for raising and lowering the jib. According to the invention, the rising and falling jib 1 is provided at its outer or free end with an extension member 8 sliding on it and carrying the hoisting rope pulley 9 and held up by means of a wire rope 10 wound on to a drum or drums 11 driven by the luffing motion, the drum or drums 11 being so proportioned to the luffing drum or drums 4 as to cause the rope 10 to lower or raise the jib extension member 8 when raising or lowering the jib in such a manner as to ensure horizontal traverse of the load. (*Sealed.*)

221,160. J. Hughes, Tonyrefail, and D. L. Thomas, Cardiff. Hoisting Devices. (1 *Fig.*) March 17, 1924.—The invention relates to movable hoisting devices and particularly to devices of the type in which a vertical adjustable crane post is mounted on a vehicle and is adapted to rest on the ground for the purpose of obtaining stability. The tram *a* is provided with the ordinary draw-bar *b*. A detachable bracket *c* provided with a depending angle plate *d* and carrying a hand-operated winch *e*, is hung on one end of the tram *a*. The bracket *c* is secured to the draw-bar *b* by a shackle *f* and a screw-threaded bolt *g*. To the other end of the tram is secured a tubular pillar *h* having a base *j* to rest on the ground and a flange *k* at its upper end. The pillar is secured to the upper part of the tram by a clamp *l*, an angle plate *m* being bolted



to the clamp *l*. The pillar *h* is secured to the lower part of the tram by a clamp *n* secured to the draw-bar *b* by a pin passed into the shackle hole in the draw-bar. Telescopically arranged in the tubular pillar *h* is an extensible member *p* on which is mounted a head-piece *q* provided with a pulley *r* and a pin *s*. From the pin *s* is suspended a pulley block *t* and a fall block *u*, the latter capable of being connected to any article to be moved, lowered or handled. Clamped on the pillar *h* is an arm carrying a rope guide pulley *w*. A rope *x* passes around the pulleys *r*, *t*, *u* and *w* to the winch *e*. The arrangement of the rope in its mode of conduct to the winch, namely, in right-angled disposition, creates a downward vertical pressure on the pillar in the operation of the appliance, which pressure tends to consolidate the pillar in a vertical position and obviate canting. (*Sealed.*)

MINING, METALLURGY AND METAL WORKING

220,670. M. McC. Bidder, Leeds. Cutting Metal. (3 *Figs.*) February 23, 1923.—The invention relates to apparatus for use in cutting metal by means of flame from a burner which is guided by a roller co-operating with a track formed on a template. Flame-cutting apparatus, according to the invention, comprises a carrier *a* provided with a flame cutter *p*, with one or more guiding rollers *d* mounted to turn about vertical axes, and also with roller or ball castors *n* whereby the carrier *a* can be supported by and caused to travel freely in any desired direction over a former A having a plane upper surface and a guiding edge. This is shaped to suit the shape of the cut to be made in a metal

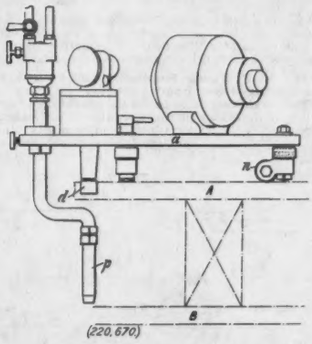
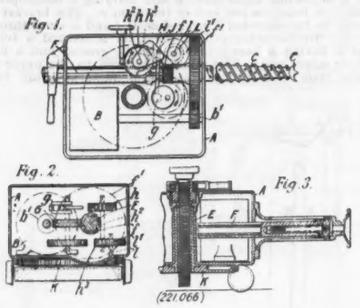


plate B by the flame cutter *p* and against it the guiding rollers *d* can be constrained to travel when the apparatus is in use. In order that the guiding rollers *d* shall, in all positions of the carrier *a*, be held closely against the guiding edge of the former A they may be made of magnetic material and be adapted to constitute magnetic rollers, so that the rollers will be kept in close contact with the periphery of the former A by magnetic attraction. The flame cutter *p* consists of a nozzle, as usual, arranged with its axis in alignment with that of the guiding roller *d*. The former A is made separate from the carrier *a* and from the plate or work B to be cut, but may, in some cases, be supported by or connected to the latter. (*Sealed.*)

221,066. J. Lithgoe, Rawnscliffe, Wakefield and J. Linneker, Micklefield, near Leeds. Coal-Cutting Machines. (3 *Figs.*) August 2, 1923.—The invention relates to coal-cutting machines of the type used for heading, boring, tunnelling or drilling, and known generally as heading machines, the machine comprising a rotating power driven cutter bar having a longitudinal feeding motion and power driven gear by which the

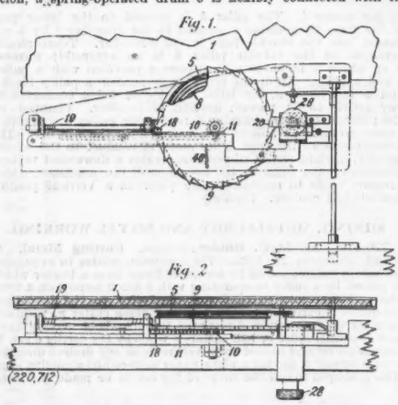
cutter bar may be slewed round a transverse or vertical axis. According to the invention, the slewing gear from the power drive of the cutter bar is arranged for a quick return on reversal. The machine embodying the invention comprises a motor B, usually an electric or compressed air motor, driving through gearing *b1*, *f1* a cutter arm or bar C carrying cutter picks *c*, the motor and gear being enclosed within a metal frame or box A carried on a movable trolley. The body of the machine is arranged to slew around a substantial centre post E, the cutter bar therefore describing an arc of a circle when being slewed from side to side. The cutter bar is moved forward into the cut independently of the slewing gear, and the slewing operation



is effected by a separate gear set. In a convenient construction of slewing gear, a worm *f*, on a splined shaft F, which drives the cutter arm spindle, with freedom for axial movement of the latter, drives a worm wheel G, carrying a crank *g* connected to a rocking member H having a pawl engaging a ratchet wheel *h*. On the shaft A2 of this ratchet wheel *h* is a pinion *h*3 gearing (for the relatively slow slewing movement) with an intermediate wheel J; this meshes with a spur wheel *l*1 on a shaft *l* carrying the main pinion L gearing with a large externally-toothed stationary gear wheel K on the slewing post and carried by the trolley, the intermediate wheel being displacable into gear with a high speed wheel for reverse. (*Sealed.*)

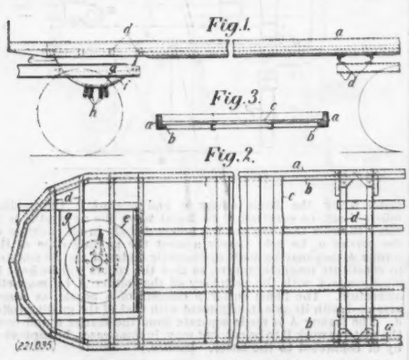
MOTOR ROAD VEHICLES.

220,712. R. E. Tompkins, Wolverton. Sliding Windows. (3 *Figs.*) May 23, 1923.—The invention relates to spring drum gears for actuating sliding windows. According to the invention, a spring-operated drum 5 is flexibly connected with the



window 1 and a lock or latch 20 engages and holds the drum 5 inoperative. The lock or latch 20 when actuated releases the drum 5 and brake gear then becomes operative being rendered so by the lock or latch driving mechanism. (*Sealed.*)

221,035. E. R. Foden, Sandbach, and Fodens, Limited, Sandbach. Six-wheel Road Vehicles. (3 *Figs.*) June 22, 1923.—The invention relates to the six-wheel type of motor road vehicle having the trailer platform supported by the longitudinal frame members of the trailer, which frame members form the side rails of the platform. The longitudinal frame members *a* of



the trailer serve as the side rails which carry the trailer platform. The longitudinal members *a* are of the usual channel section Within the channels are fixed "L" shaped wooden members on to which the platform *c* is secured. The longitudinal fram members are stiffened by cross girders *d* at the parts which com over the front and back axles. The cross girders at the fron carry a saucer-like part *e* having a flange around its upper edge and a gap in the base. The saucer-like part seats in a corresponding saucer *f* carried by the rear end of the motor chassis portion of the vehicle. A further saucer-like part *g* is placed within the upper saucer and springs *h* are provided to hold the saucers in frictional contact with one another. A guide is provided for the saucer *e* carried by the front portion of the trailer, which can have universal movements relatively to the motor chassis to adjust itself to any irregularities in the road surface transmitted to the trailer rear wheels, whilst being efficiently propelled from the motor chassis. (*Sealed.*)

PUMPS.

221,164. Swan, Hunter & Wigham Richardson, Limited, Walker, Newcastle-on-Tyne, F. Rowntree, Monkseaton, and P. Belyavin, Jesmond, Newcastle-on-Tyne. Automatic Valves. (6 *Figs.*) March 28, 1924.—The invention relates to an improved construction of automatic valve for use with pumps. The invention relates to a valve of the flexible plate type and comprises a stop plate and a seat plate for the flexible valve plate and a distance piece separating the stop and seat plates and provided with recesses which receive the ends of the flexible valve plate. Guides on the stop plate for the ends of the flexible plate may extend into the recesses. A is the flexible valve plate, three such plates being indicated in the construction of valve illustrated. B is the slotted seat plate having the slots *b* corresponding to the three valve plates A, but substantially narrower and shorter than the valve plates. *c* is the stop plate. D is the distance-piece inserted between the edges of the stop plate *c* and the seat

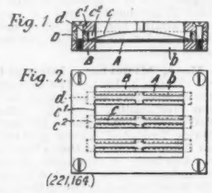
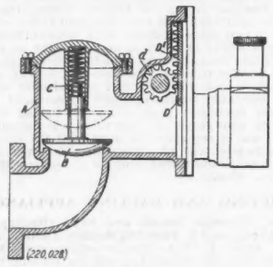


plate B, the two plates and distance piece being secured together by screws which screw into the seat plate as indicated in Fig. 1. The stop plate *c* is formed with three stop members between and outside which are the slots *c*1 through which the air from the valves escapes, the stop member *c* being cast in the form of ribs extending across the stop plate. The distance piece D is in the form of a frame having a large open space giving free passage for the air and provided with three pairs of recesses *d* which accommodate the ends of the three corresponding valve plates A. The ends *c*2 of the stop members *c* project, as shown in Fig. 1, into the recesses *d* and hold down the ends of the valve plates, while the under surface of the members *c* is of arched form corresponding to the outline taken by bending up the flexible valve plate A by fluid pressure from below, so that when a valve plate is pressed up sufficiently far to meet the lower surface of the stop *c* it follows closely the form of the stop surface and is supported at all points. (*Sealed.*)

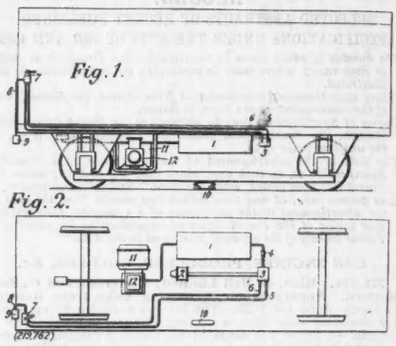
220,028. John Morris and Sons, Limited, Salford, Manchester, J. Morris, Salford, Manchester, and F. Morris, Salford, Manchester. Fire Engine Pumps. (2 *Figs.*) May 1, 1923.—The automatic priming delivery and back-pressure valve forming the invention for use with turbine pumps on fire engines, comprises a casing A, a valve guide *c* arranged therein, an automatic direct lift back-pressure valve B adapted to be held



closed by the pump vacuum during priming and opened by the pressure of the water when lifted, and a slide valve D controlled by a rack and pinion D1, *d* on the delivery side of the automatic back-pressure valve B to shut off water and a handle on the pinion spindle to operate the slide valve. When the pump is stopped the valve B automatically drops upon its seating and water seals the pump, obviating the necessity of repriming the pump during short stoppages. (*Sealed.*)

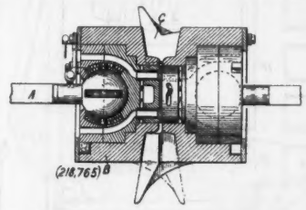
RAILWAYS AND TRAMWAYS.

219,762. The English Electric Company, Limited, London, and C. E. Fairburn, London. Vehicles for Use on Rail Traction Systems. (2 *Figs.*) May 10, 1923.—The invention deals particularly with the provision of braking power on electrically-driven trains which are not provided with continuous brakes, for instance, in goods traffic. In accordance with the invention, an electrically-operated braking vehicle is provided separate from the driving vehicle or electric locomotive and it has means for applying, during the running of the vehicle, motive power for operating a brake system on the said vehicle, this sytem being a compressed air or vacuum system. 1 is the air reservoir, 2 the brake cylinder, 3 the emergency valve of known type, 4 the safety valve, 5 and 6 the usual emergency and train pipes leading from the valve 3 to the brakesman's controlling valve 7 of known type, and 8 a pipe connecting the valve 7 to atmospheric pressure through an exhaust muffler 9. In well-known manner if it is desired to apply the brakes suddenly and fully, the valve 7 is moved so as to connect the emergency pipe 5 to atmosphere and this causes the emergency valve 3 to connect the air reservoir 1 to the brake cylinder 2, whereby the brakes are applied. If, on the other hand, it is wished to apply the brakes gradually and with varying force, the valve 7 is moved so that it gradually connects the train pipe 6 to the emergency pipe 5, and this causes a gradual admission of air under pressure from the reservoir to the brake cylinder. Any known modification of this part of the controlling apparatus may be employed, and the air reservoir 1 and the associated parts may be adapted for vacuum working if desired. In accordance with the invention, the motive power is obtained by arranging a



current collector 10 on the vehicle, and thereby supplying current to an electric motor 11 which drives a compressor or vacuum pump 12, associated with other parts of the power brake mechanism and control gear on the vehicle. (*Sealed.*)

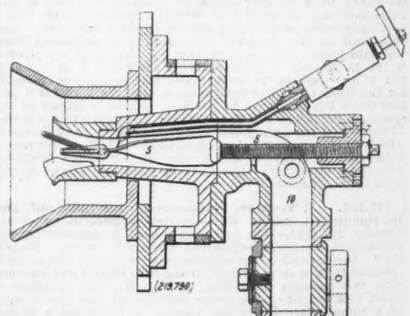
218,765. H. W. S. Husbands, Stamford Hill, London. Automatic Couplings. (5 *Figs.*) April 18, 1923.—The invention relates to automatic couplings of the wrist action type and has reference to couplings in which the head portion B comprises three claw-like members C each having a cam surface adapted to engage the corresponding cam surface on an identical and opposite head when the two couplings come together, whereby each head is partially rotated against the action of a spring, so that the hook or claw-like portions engage and lock the two couplings together. A wrist action coupling, according to the invention, comprises a draw-bar A connected to the vehicle and provided with both buffer and draw springs, having a coupler head B with three projecting hook or claw-like members C thereon



and a universal joint between the head and the draw-bar, so constructed as to enable the head, even prior to being coupled, to rock in any direction upon the bar A without rotating relatively thereto. Means are provided for releasing the coupling from either side of the vehicle and for holding the coupling in a disengaged position, as, for example, for use in shunting, and preferably some flexible power transmission device, such as a Bowden wire mechanism, is employed for this purpose. Further, besides constituting a single central buffer and combined coupling for the two vehicles, in some cases if desired, the steam or brake train pipes and electric conductors may be so mounted on the coupler head as to be automatically coupled when the two opposite vehicles come together. (*Sealed.*)

STEAM ENGINES, BOILERS, EVAPORATORS, &c.

219,790. Henry Wilson and Co., Limited, Wapping, Liverpool, and H. Foden, Wallasey, Cheshire. Liquid Fuel Burners. (1 *Fig.*) June 28, 1923.—The invention has reference to liquid fuel burners of the type in which liquid fuel is supplied by a pipe into a tube or conduit from which it falls by gravity and is carried or atomised by a swirling current of air, which is forced past the falling liquid and projected from the end of the tube or conduit. In a liquid fuel burner according to the invention, the fuel is delivered and falls by gravity on to an open plate 5 at a point at or near the restricted or throat part of the air delivery duct 10 so that the liquid fuel is subject to the action of the whole body of the air passing through the



duct. The plate 5 is preferably of a twisted or helical form so as to impart to the air in its motion through the apparatus a whirling motion. The pitch of the helical plate 5 is long and extends both in front of and behind the end of the oil pipe 1 which is at the top of the main mixing and atomising conduit or tube, and the plate 5 is supported by a stem or rod 8 from a cap 7 fastened to the front end of the body of the apparatus. Where it passes through this cap the stem is threaded so that it can be screwed in and out and adjusted as required. This hollow end of the body of the apparatus, and the helical plate in the centre of the mixing tube, are in line. (*Sealed.*)